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SCIENTIFIC REPORTS

OF THE

Imperial Agricultural Research Institute, New Delhi

For the year ending 30th June, 1938

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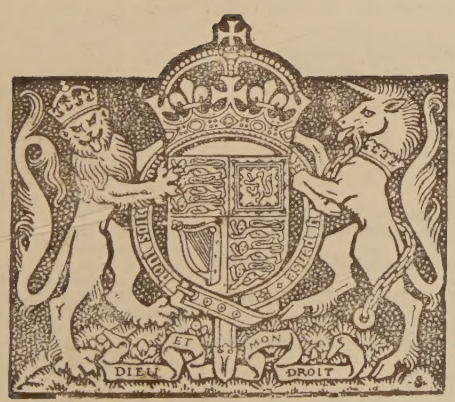

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OF THE

Imperial Agricultural Research Institute, New Delhi

FOR THE YEAR ENDING JUNE 30, 1938

REPORT OF THE DIRECTOR

(B. VISWA NATH)

This is the second report after the transfer of the Institute from Pusa to New Delhi towards the end of the year 1936.

During the year under review the levelling and layout of the agricultural area at Delhi was completed. An area of 380 acres is available to meet the demand for food and fodder of about 300 head of cattle and the needs of field experimental work. At the substation at Karnal the *batai* system was terminated and an area of 1,175 acres was brought under direct cultivation. The laying out of the experiment fields and the equipment of the laboratories for research in the various branches of agricultural science having been completed, the different Sections of the Institute were enabled to resume their normal activities which were interrupted first by the earthquake in January 1934 and afterwards by the transfer to Delhi.

I. INTRODUCTORY

The Institute, as a central research organisation, will assist in the future, as it had done in the past, in the further development of Indian agriculture on a broad scientific basis. The primary function of the Institute is to carry out that fundamental investigation and advanced instruction which are usually outside the scope of similar institutes and laboratories in other parts of India. It can also assist in the progress of research by testing and developing suitable methods for the sampling and analysis of soils and crops, by testing and developing designs for field experiments, by the collection and study of insect pests and disease-producing organisms associated with crops, and by giving advice and assistance to centrally administered areas.

Research is the basis on which a sound system of agriculture can develop, and the demand for research must expect to be followed by a demand for facilities for post-graduate instruction to maintain a steady supply of trained workers. It is only fitting that, in a great agricultural country like India, the supply of trained workers should come from an institution within the country.

Increased facilities for post-graduate training in the different branches of agricultural science are, therefore, made available at the new Institute at Delhi. More hostel accommodation has been provided. The courses of instruction have been suitably modified in the light of past experience and having regard to the needs of new scientific farming and to the advances in the different branches of agricultural science. Stress has been laid equally on laboratory and field work and on the development in the student of a wide scientific and practical outlook, so that practical problems may be first resolved into their scientific components before an attack over a wide front is made by the cognate sciences.

The future programme of research and investigation is necessarily, to a great extent, the continuation of, or the corollary to, the work in progress, with such modifications or additions as are demanded by current problems and the trend of future developments. Thirty years ago, when agricultural research began in this country, the Institute was the only one of its kind in India, and the knowledge and experience then available in Europe and America was the source of inspiration and guidance in the initiation of agricultural research in this country. As research advanced and as experience, under varied conditions of soils, climates and crops, was gained, it has come to be realised that the nature and intensity of the processes are different in tropical and temperate regions and in the crops that grow in them, and that, therefore, the practices developed on the basis of results obtained in temperate regions cannot always be directly applied to tropical conditions.

In the report of the Institute for 1936-37, the progress of research at the Institute during the past three decades and the scientific and economic value of the results were described. From the point of view of practical and economic agriculture the position can be simply and briefly stated thus. Past research has not only placed increases in yields of crops within the bounds of possibility but has actually enabled their realisation. A stage has now been reached at which the limiting factor in further increase in yield is the fertility of the soil and not the capacity of the improved and high yielding variety of seed. It, therefore, follows that further crop increase must remain potential until the general level of soil fertility and cultivation are improved. These call for further research and investigation on problems of soil fertility, cultivation and plant nutrition and in the ways of protecting crops from damage by insects and disease.

In recent years there have been many developments within the agricultural industry itself. The peasant farmer has begun to appreciate the results of scientific research and has been responsive to changes in methods and crops to the limit of his financial resources. The economic significance of Indian agriculture is not now confined to the production of food crops. The industrial and trade expansion, the extensions of irrigation and transport facilities, brought in their wake intensive cultivation, and the development of power farming. Crops like wheat, cotton, sugarcane and tobacco are cultivated on estate basis. The movement for marketing organisation and the introduction of grade standards demand in agricultural produce quality for trade and quality for industry. A more recent and a very important development is the interest in national nutrition which calls for the production of sufficient food with high nutritive quality.

Knowledge in the different branches of agricultural science has not developed at the same rate, but there have been advances in all the branches. New knowledge and new methods of greater sensitivity and precision are available for employment in the study of new problems or for the re-examination of older ones to greater advantage. The advances made in some branches are such that even the theoretical foundations of the past appear to need radical revision. These and the problems for study which have been taken up, having regard to the work in progress in the provinces and States, are discussed in reviewing the work during the year. Details will be found in the reports of the Heads of Sections of the Institute. Some of these reports contain, besides the work during the year under report, reviews on selected investigations either because of their bearing on problems under study or have reached a stage at which the work of some years can be usefully summarised.

II. RESEARCH AND INVESTIGATION

1. Mixed Farming—Crop and Animal Husbandry

Mixed farming has been an important line of study even from the early days of the Institute, when its value to Indian agriculture was not generally recognised. Research and experience has, however, begun to effect a change in the older views on soil fertility, and it has now come to be generally recognised that the best means of building up and maintaining the fertility of Indian soils lies in the direction of the judicious blending of crop and animal husbandry, which are the two interdependent branches of mixed farming as against estate farming, in which large areas are farmed with power implements and in which cattle play an insignificant part.

The theory and practice of mixed farming as a means of maintaining soil fertility, which is the main link between land and stock, must continue to receive careful and sustained attention.

(a) Crop Husbandry

During the year, along with the production of food and fodder for the stock, adequate arrangements have been made for the improvement and maintenance of soil fertility by fallowing, green-manuring, application of organic manures and fertilizers, and the introduction of leguminous crops in the rotations.

Trials with several crops were made to ascertain if the work on cereal crops and pulses could be continued from the point where it was left at Pusa, or whether the previous work had to be discarded owing to soil and climatic differences. The results have been satisfactory. The crop yields were as good as those at Pusa and in some cases the yields were even higher, as will be seen from the comparative statement below.

Crop.	Yields per acre in maunds (82·3 lb. = 1 maund)	
	Delhi	Pusa (Average of last 5 years)
Berseem, green fodder	486	294
Oats	27	15
Wheat, P. 12	18	12
Barley	30	17
Peas	15	9
Maize	5	12

Fodder investigations.—Attention was paid during the year to the important problems of fodder crops, such as production of pure berseem seed at a cheaper rate, water requirements of berseem and the yields of alternative fodders. Berseem is the best of fodder crops and is also a soil improver, yet it has not spread though introduced three decades ago and has not gained popularity with the farmer. Two reasons appear to be responsible for this. One is that the crop's irrigation requirements are high, and the other is that reliable seed at a cheap rate is not easily available. Experiments laid out at Delhi and Karnal show that the maximum quantity of seed is obtained if the crop is left to seed after the third cut in February. Delhi and Karnal stations are now in a position to supply pure berseem seed at a reasonably lower price than has hitherto been possible.

The results of irrigation experiments with berseem indicate that, on a medium loam soil, irrigation once in twelve days is as effective as irrigation once in eight days.

In comparative experiments with alternative fodder crops the following yields were obtained.

	Mds. per acre.
Berseem	223
Kerao (field pea)	226
Barley and Kerao	144
Khesari (*Lathyrus sativus*)	192
Methra (*Trigonella* sp.)	76
Senji (*Melilotus parviflora*)	103

At the Pusa Substation, a few strains of oats—an important fodder crop which can be grown successfully over a wide range of soils and climates—was grown for its green fodder.

At the Sugarcane Station at Coimbatore, *Sorghum halepense* was successfully crossed with *Saccharum* in the attempt to produce canes useful as fodder. The hybrids show the soft leaves of *Sorghum halepense* and flower in three months, but the vegetative vigour is far from satisfactory. Further crosses with *Saccharum* and other parents are contemplated to introduce growth vigour.

Sugarcane.—Seventy-five varieties were grown on the Delhi farm. Al the varieties were analysed periodically between December and April, and they showed poor results in sucrose content throughout the season. The only variety which went up to 18·10 per cent sucrose in March was Co.313. Most of the heavy tonnage canes, except Co. 313 and Co. 421, showed poor sucrose content.

In comparative manurial experiments no significant difference in yield was observed between sulphate of ammonia and sodium nitrate, although the latter gave slightly more yield of cane. Application of the fertilizers in two doses was better than in one dose. Rape cake at 40 lb. nitrogen and superphosphate at 50 lb. phosphoric anhydride to the acre, gave higher tonnage and paid for the cost of fertilizers than with the other proportions of nitrogen and phosphate. The same quantities of nitrogen and phosphate as ammonium sulphate and superphosphate together with 40 lb. of potash as potassium sulphate did not give satisfactory yield unless the land was previously manured with green manure (sann-hemp). Experiments during four years at Pusa on maize, oats, peas,

wheat and gram showed that a concentrated manure like rape cake at 40 lb. nitrogen to the acre was better than 8,000 lb. of farmyard manure (40 lb. nitrogen) for summer crops, while for the winter crops there was no difference between rape cake and farmyard manure. Complete artificials alone supplying 40 lb. nitrogen, 80 lb. phosphoric acid and 50 lb. potash, came up to the level of farmyard manure in some years. Potash did not appear to increase the yield of any of the crops tested.

In experiments with green manures, *C. muijussi* was the best among the different species of *Crotalaria*. Sann-hemp (*Crotalaria juncea*), *dhaincha* (*Sesbania aculeata*), *guar* (*Cyamopsis psoralioides*), cow-pea (*Vigna catjang*) and velvet-beans proved better legumes than soyabean. Green manure with superphosphate was distinctly better than green manure alone, and there was no difference in the manurial values of superphosphate and bone-meal when applied with green manure.

On small-sized plots leaves of green manure appeared to possess better manurial value than the whole plant or its parts, but on a large field scale no difference in the yield of oats was observed between manuring with leaves alone and with the entire plant.

The experiments at the substation at Pusa did not show any superiority in fermenting mustard cake before application as manure. On the other hand, the indications were that fermentation reduced the manurial value of the cake.

(*b*) *Animal Husbandry*

The Sahiwal herd, which consisted of 13 breeding bulls, 71 cows, 44 young males and 65 heifers at the end of the year under report, settled down in its new home, and it is now possible to assess the effect of transfer of the herd from Pusa in October 1936. Considerable improvement is noticeable in the health of all classes of the stock, and it has been possible to initiate further experiments. The average milk yield of the herd at the end of the year was 22·2 lb. per day as against 20·7 lb. for the corresponding period in 1936-37. The Sahiwal cattle exhibited at the All-India Cattle Show at New Delhi in February 1938, took first and third places in bulls, and first and third places in heifers—a very good testimony when it is realised that the animals bred in Bihar made their first appearance in competition against cattle from the home of the breed.

All the improvements made with the Sahiwal herd in feeding and handling and general management have been in practice at Karnal with the Tharparkar herd, which is now the practical expression of the results obtained with the Pusa-Sahiwal herd at Delhi. The Tharparkar cattle won three first and three second prizes at the Delhi Show.

The demand for pedigree cattle continues to be as high as ever. Thirty-five head of Sahiwal cattle and 51 head of Tharparkar cattle of all denominations were sold during the year under report.

Early maturity experiments.—In the Sahiwal breed the heifers do not take the bull till they are 2½ years old and the bulls are not able to serve before the age of three years. This late maturity of heifers and bulls has been a great handicap in the introduction of proved bulls, as it would take nine years to know the performance of their progeny. Experiments were therefore started in 1932 to see if late maturity was inherent in the breed, and whether early

maturity could be induced by suitable feeding and handling. These experiments have proceeded steadily and there is now progeny from bulls 19 months old and heifers of about the same age. The experience and the data collected during the past six years show that early maturity can be produced with its great increase of time in profit and there is no sign of deterioration so far.

The percentage of early maturity milch animals at the end of the year under review was 73 against 27 ordinary animals. The average milk yield has steadily risen from 13·6 lb. in 1931-32 to 22·2 in 1937-38. The average weights at the first covering time were 736 lb. and 637 lb. respectively for ordinary and early maturity animals. In subsequent lactations these differences tended to even out and the weights at the 22nd week of lactation were :—

Control animals lb.	Early maturity animals lb.
823	783 first lactation.
876	890 second „
913	894 third „

Early mating does not affect the development of the calf at birth, and newly born calves are in no way inferior to the calves from control animals as is evident from the average weights of calves at birth—

	Control lb.	Early maturity lb.
Wt. of calf at 1st calving	47·3	45·3
Wt. of calf at 2nd calving	50·2	50·2
Wt. of calf at 3rd calving	53·3	50·8

The percentage of calf mortality in the early maturity ones was 3 per cent. in 1931-32 and 1·5 per cent. in 1937-38. Early maturity progeny can in no respect be considered inferior to the ordinary late maturity progeny in appearance, stamina or in milk yield per lactation. It would appear that early maturity, by increasing the number of lactations, naturally gives increase in live stock and total milk yield in an animal's life without in any way affecting the animal.

Other investigations.—Considerable attention was paid to work on skeletal alterations and to studies on transmission of characters, full brothers and full sisters parallels and stimulation before and after pregnancy and its effect on milk yield in heifers.

The work on skeletal alterations in the Sahiwal breed has reached a stage in which similar work can profitably be started on other breeds. The results obtained so far are being published in the form of a paper. Many of the so-called characteristics of the Sahiwal breed have been bred out, retaining at the same time the milk in a better hung vessel on a high yielding cow.

Interesting results have been obtained from stimulation experiments. Stimulating uncovered heifers resulted in milk yield, and the data available at the time of writing show that the milk is normal in composition and nutritive value and that pregnancy appears to be unnecessary for milk secretion. Stimulation of the act of milking and handling has apparently a much greater effect than was hitherto supposed.

2. Plant Breeding

Progress in the production, for high yield, of new varieties of crops by selection and hybridization has been satisfactory, and economic results of considerable value have been obtained. The next step in advance is in the direction of breeding crops for resisting disease and drought. A stage has now been reached at which breeding crops for drought and disease resistance is impossible without obtaining knowledge on many connected problems. Sustained cytological investigations on Indian crops are necessary for understanding modern theories of heredity and their application in the further advance in plant breeding, particularly in breeding for drought and disease resistance. It is important to know how the genes, which are the ultimate units of heredity, bring about the development of the various characters in plants. Success in analytical genetics has been obtained with the numerous deleterious recessives which are abundant in most species and with certain easily recognisable characters of no great practical value to the plant-breeder who is primarily concerned with the quantitative characters, *e.g.*, yield, which thus far have shown themselves intractable by the familiar genetic methods, although it is abundantly clear that the development of these characters does depend on the genic entities. The study of these characters is of fundamental importance, as also the study of mutations which is fundamental to the understanding of the developmental physiology which may have considerable importance on agricultural practices. The progress of work on breeding improved varieties of crops is discussed under two headings—sugarcane-breeding for which there is a special station at Coimbatore and other crops which were dealt with at Delhi and at the substations at Karnal, Pusa, Simla and Guntur.

(*a*) *Sugarcane*

Sugarcane-breeding work at Coimbatore is carried on for sub-tropical and tropical areas of India. The chief requirements of the varieties required for sub-tropical India are hardness to withstand intense hot and cold seasons. The very first efforts employing as parents cultivated *saccharums* were unsuccessful, as the seedlings were unsatisfactory in many respects. The next step was the successful introduction of the wild cane *S. spontaneum* into the parentage, and a direct cross with Vellai resulted in the production of the seedling Co. 205 which was then a good commercial proposition. This was quickly followed by Co. 210, Co. 213, and Co. 214 which were first tested and multiplied at Pusa for distribution. A great deal of further research work was directed towards the improvement of the earlier batches of thin and medium canes, and subsequently to the breeding of thick canes for the tropical areas of India. Among the recent canes which are doing very well in different parts of India are : Co. 312 and Co. 313 in parts of the Punjab and United Provices, Co. 299 in Bihar, Co. 419 in many parts of tropical India ; and among the intergeneric sorghum hybrids Co. 352 and Co. 356 are promising in Madras, United Provinces and Bihar under certain conditions. Co. 421 has done particularly well in sub-tropical India. Some of these varieties are making a name even outside India. For example, Co. 290 won the Grand Prize in Hawaii for possessing the biggest stool ever produced anywhere with 360 canes to the stool, standing 30 feet high, weighing two tons in raw material, and yielding 400 lb. of commercial sugar.

After the production of improved canes suitable for various tracts and their spread in cultivation attention has been directed to the production of early and late canes, canes which would not lodge in cultivation, canes that would not flower freely and canes that would resist diseases, pests and other adverse conditions. The sugarcane industry, after establishing itself on the available raw material, is demanding quality as well as quantity of cane. There is now a more pronounced demand for early, mid-season and late varieties of canes, and importance is also attached to the keeping qualities of canes during transport. The investigations in this regard are dominated by the constant search for parents that are known to possess certain desirable characters, and by endeavours to secure as wide a range of parents as possible to bring in new genes through intergeneric hybridization. These efforts were successful first in 1930 with the sugarcane-sorghum cross which has since been successfully repeated in Hawaii, Java and Florida. Towards the end of 1936 successful crossing was effected between sugarcane and bamboo—two parents which are wider apart than those hitherto recorded in this type of hybridization as the two parents belong to different subfamilies of the gramineæ. It is too early to speculate on the economic possibilities, but evidence is accumulating to indicate that the introduction of the sorghum parent has brought in certain useful characters. A new line of attack in sugarcane-breeding has been opened up and its special feature is the introduction of new genes not available in *Saccharum*.

Sugarcane-bamboo cross.—Many of the sugarcane-bamboo hybrids raised last season flowered profusely and some of them freely set seed. Two of the most interesting of these hybrids and those that showed definite bamboo characters have given over two hundred plants in the F_2 generations. The fertility of these hybrids is a valuable asset, as it renders possible further crossing with other desirable parents. About ten trigeneric hybrids between the sugarcane-sorghum and bamboo were raised during the year under report, and these complex hybrids have quickly established themselves. When the sugarcane-bamboo hybridization was announced, the fear was expressed in many quarters that the hybrids might take after the bamboo and prove too hard to the mill. One important feature associated with inheritance of characters when the sugarcane is used as the mother parent is the wide variation even in the F_1 generation. While a few are quite hard-rinded, there are others as soft-rinded as the sugarcane and also possessing certain useful bamboo characters. As such seedlings are multiplied in cultivation through vegetative means, they retain practically all the characters. Nearly a thousand hybrids are growing and the plants are proving to be of great interest from the scientific and economic points of view. From among this population there are some seedlings distinctly superior to the standard Co. 213 and Co. 281 in vegetative characters. The preliminary tests for sugar content are encouraging. Another encouraging feature is the habit of some of the hybrids, which is a very important field character. P. O. J. 2878 gained its reputation by its tall, straight, erect canes. Some of these F_2 generation plants have this character combined with marked tillering power.

For breeding thick class of canes for tropical areas, Co. 419 and Co. 421, which are rapidly gaining in reputation, have been kept as standard. During the year seventy-eight crosses were effected. In plot tests over thirty seedlings gave promise as early canes and twenty-five as late canes. Eleven seedlings Co. Nos. 446-456 passed the station tests and qualified themselves for

distribution for trials in the several experiment stations in the provinces. At Karnal Co. 395 definitely showed itself suitable for extended trials. It is an early cane, capable of withstanding drought, and possesses good habit and satisfactory juice quality.

At present sugarcane setts are sent out for trial after they are grown and tested at Coimbatore. In order to save time the possibility of growing seedlings under North Indian conditions has been under trial at Shahjahanpur and Karnal since 1932 either by sending out sugarcane seeds preserved in an atmosphere of carbon-dioxide or as seedlings suitably hardened for the journey. So far no appreciable advantage has resulted from such work. The period of experimentation is probably not enough for valid conclusions.

(b) Improved varieties of crops other than sugarcane

Part of the work was done during the year at Pusa and Karnal. Towards the close of the year the work at the latter place was transferred to Delhi. Increasing attention was paid to the genetical side and in breeding work stress has been laid on disease resistance.

Wheat.—The early productions Pusa 4, Pusa 12 and Pusa 52 still continue to be popular in wheat-growing tracts. They are the dominant wheats in the North-West Frontier Province, the United Provinces, in Bihar and in Orissa. In recent years further improvements have been made, and wheats which combine high yield with good milling and baking qualities, strong straw and resistance to rust and economy in use of water have been produced. Pusa 111 equals good Manitoba wheat in milling and baking qualities. Pusa 120 and 165 come very near to Pusa 111 in these qualities.

The work on the breeding of wheats which can resist rust disease was continued at Simla, and F_3 populations of a number of crosses were tested for resistance in the seedling stage by Rai Bahadur Dr. K. C. Mehta. After this the plants were set out in the field and further studied. The strains of wheat produced are expected to be suitable for growing both in the hills and in the plains where wheat is grown. The study of several new crosses and the maintenance of the collection of foreign wheats were continued. Work on the development of strains of wheat immune from or highly resistant to loose smut and flag smut is being undertaken. The study on the influence of certain external factors upon heterosis in wheat was completed.

Oil-seeds.—The genetical work with linseed this year confirmed the existence of a single factor difference between the normal green and the yellow-tipped mutant type. Selections were made for types combining rust resistance with other economically important characters. The crosses between linseed and flax for producing strains to supply both fibre and seed were also under study. Work on the breeding of high-yielding white-seeded types of sesamum was on hand, and investigations on oleiferous *Brassicae*, and self-compatible, self-incompatible and cross-compatible groups and pseudo-fertility were in progress.

Legumes and Pulses.—The breeding of pigeon-pea varieties which combine resistance to wilt disease with other desirable qualities was continued, and data on the mode of inheritance were collated.

Fibre crops.—Four fixed hybrids between New Hibiscus and Albus were grown for comparative tests. A number of cotton varieties were also grown and some crosses were made.

Potato.—The work on this crop was continued both at Delhi and Simla, and attention was chiefly paid to the study of disease-resistant types. A large number of plants resistant to late blight were found in progenies of crosses between *Solanum tuberosum* and *S. andigenum* and between *Solanum tuberosum* and *S. demissum*. The resistance of these cultures will be more severely tested. About 50 cultures of potatoes from the Indian collection, 276 samples of Chilean *tuberosum*, 22 species of tuber-bearing *Solanums* and a large number of interspecific hybrids were selected for detailed study. For breeding potatoes for high starch some samples were analysed for their starch content. The starch content of the required samples varied from 12 to 23 per cent, showing ample variation for breeding for high starch content.

Tobacco.—Till a few years ago, the trade demand was for light and bright-coloured tobacco leaf for the cigar industry. With rapid increase in cigarette smoking an ever-increasing demand has developed for cigarette tobacco. None of the indigenous tobaccos having been found suitable for the production of cigarette tobacco, suitable hybrids H. 142 and H. 177 have been produced by crossing one of the best of the indigenous varieties with the American variety Adcock.

The value of cigarette tobacco is determined by its quality, and tobacco is crop which responds to a greater degree than grain crops to such factors as soil, fertilizer and climate and the process of curing the leaf after harvest. A sub-station for the study of these factors was opened at Guntur with financial assistance from the Imperial Council of Agricultural Research. Preliminary experiments were carried out to test the effect of fertilizer constituents individually and in combination and also to test the effect of rotation on the quality of the leaf.

Tobacco leaf contains an alkaloid nicotine which has been found to be a valuable insecticide. Tobacco with high nicotine content is therefore a good commercial proposition. With a view to produce strains of tobacco which combines heavy yield with high nicotine content, the available types of *N. rustica* are under study.

3. Soil Problems

There are many soil problems concerned with land reclamation, land amelioration, soil management, fertilizer practice and in general the maintenance of soil conditions suitable for crop growth. The studies of these problems have one aim, namely, the maintenance of the productivity of soils that are already rich and raising the productivity of those that are inherently poor. Most of the problems are governed largely by local conditions and are, therefore, best studied locally, but the basic principles underlying the productivity of soil can be understood only from a comparative scientific study of the soil by itself and in relation to agricultural practices over a wide range, and this can best be done at a central institution.

Soil research in India during the past three decades has been fruitful in devising such schemes of soil management and fertilizer practice as would increase soil fertility. At first there was neither scientific nor field data for Indian soils, and therefore the formulation of the practical schemes was based on European standards and experience. Laboratory studies and field experience over a number of years with soils and crops in different parts of the country are now available for assessing the relative merits.

Principles and practices found valid for soils of temperate regions have been found in many cases unsuitable for Indian soils without substantial modifications. Clay soils which would be declared unfit for crop growth according to European standards are seen to yield good crops. The nitrogen and phosphate contents of most Indian soils, which grow good crops, are of an order which would be declared deficient in soils of the temperate regions. The nitrogen recuperation powers of Indian soils are far greater than those of the temperate regions. Indian soils, the lime content of which, according to European standards, is so low as to indicate heavy applications of lime, do not respond to lime treatment and in some soils the initial lime content is even too much for certain crops.

Frequent and deep cultivation of the soil, which is so widely believed in and advocated, has been found ineffective and even detrimental to crop yields in some parts of the country and under certain conditions. Surface cultivation of the soil has not been favourable to crop growth in all parts of India. River and well waters whose salt content is too high for irrigating some soils in some parts are used for irrigation of some soils without trouble in other parts, and all soils have not developed alkalinity and salinity to the same extent when put under irrigation. The response to fertiliser application is variable even in areas and conditions where moisture supply is not the limiting factor. Where response to fertiliser treatment is good, it is evident that greater fertiliser efficiency in terms of crop yields ought to be possible. Among the more important fertilisers, the problem of nitrogen supply and its fate in the soil has so far practically monopolised the attention of investigators. The subject of phosphate reserves in the soil and the relation between the chemical nature of the soil and the salts of phosphoric acid has not received the attention which the importance of the subject demands. Unlimited sources of nitrogen supply are now available and we know now, better than we did before, how to make the several sources of nitrogen available to the plant. The danger is that unwise use of nitrogenous and potassic fertilizers is likely to bring about the exhaustion of the other available minerals in the soil, particularly phosphate, supplies of which compared to nitrogen are very limited.

It is evident that, if our soil resources are to be fully and properly utilised for the increased production of crops, the reasons for the differential behaviour of soils should be fully understood. What is wanted is the comparative study of field data in the light of the laboratory data on soils. There is a large amount of scientific data on Indian soils, but the data have accumulated from isolated studies and employing different methods over a period of thirty years. To establish a genetical interconnection between the several types of soils on the basis of such data as are available and to interpret the field behaviour of the soils is not valid.

Also in recent years considerable advances have been made in soil science. The older concept of the soil as a permanent and static body which is in equilibrium with its climatic environment, is not now considered valid. The soil is now recognised as a dynamic body subject to perpetual change. The views on the chemistry and physics of the soil clay have undergone radical changes. Formerly such important properties of clays as water relationships, reaction to fertiliser and other treatments, were interpreted in terms of soil clay as an amorphous colloid. Recently soil clay has been shown to be crystalline in

nature, and more recently the structure of the constituent parts of the clay crystal has been elucidated. The properties of what is called clay of the soil are, therefore, determined not only by particle size of clay as was held in the past, but also by the mineralogical and chemical properties and by the nature of the crystalline clay minerals.

It is obvious that any further advance in the knowledge of our soils and the practical application of that knowledge must be preceded by comparative studies in the light of modern developments in soil science and employing identical methods of investigation. A systematic comparative study of the soils of the country is necessary to define soil groups and to know to what extent Indian soils fit into the modern world scheme of soil classification. Once the characteristics of the natural soil and its classification are established, it will be easy to estimate the probable consequences of the physical, chemical and microbiological actions which will result from different methods of soil cultivation and treatment and to formulate suitable schemes of soil management.

Studies of soil characteristics.—For these reasons a comparative and comprehensive study of soils from different parts of India has been taken up. It is not a soil survey in the strict sense of the term but only a general picture survey which differentiates soils and their profiles as influenced by surface geology and major climatic features. Samples of soils from uncultivated lands and from lands cultivated but unmanured have been collected from the different agricultural experiment stations in the several parts of India, it being assumed that each station represents in the main an area typical of the locality. Since the agricultural experiment stations are dotted all over India, the results when put together will give an outline map showing the general and special features of the several types of soils, and details can be easily filled in from local investigations.

During the year the laboratory examination of the samples of soils was in progress with reference to their clay composition, and such characteristics as base exchange, water soluble salts, carbon and nitrogen contents and mechanical composition. Many samples have yet to be examined and the available data are not sufficiently large to permit discussion, but the results obtained so far seem to show marked differences to justify the prevalent grouping and classification as black, red, brown, pink and laterite soils. The black soils so far analysed differ in their geological origin but are characterised by high clay contents and high values for silica-alumina ratios. The red, brown, pink and laterite soils are characterised by low clay content, low exchange capacity and lower silica-alumina ratios. The soils of the Indus alluvium show pronounced alkalinity, are rich in alkalis and alkaline earths ; the soils of the Gengetic alluvium are relatively freer from alkalis, while those of the Brahmaputra alluvium are highly leached. It is hoped that by next year more data will be available for a detailed discussion.

4. Nitrogen balance in Indian soils

Nitrogen is an important major element in plant nutrition, and crop yields will be in proportion to the supplies of nitrogen available to the crop. The maintenance of nitrogen balance in Indian soils is the one important problem. Nitrogen deficiency in the soil may be made up by the use of artificial nitrogenous manures, but that is expensive apart from the losses which are observed

to occur through leaching and in gaseous form. Past research has shown that in Indian soils the biological agencies in the soil and those in leguminous crops bring about nitrogen recuperation far more efficiently than in soils of the temperate regions. Here is then an important and inexpensive means of maintaining the nitrogen level of Indian soils by suitable tillage practices and the judicious use of leguminous crops.

Cereal crops in relation to nitrogen fixation in the soil.—A question of considerable theoretical and practical interest is, whether cereal crops fix atmospheric nitrogen in the soil as is found to be the case with leguminous crops. In the course of investigations at Pusa on the nitrogen balance in the soil under certain crop rotations, it was observed that after certain cereal crops, a gain in the nitrogen content of the soil occurred, as will be seen below from the statement of gain or loss of nitrogen.

Nitrogen fixation by crops in Pusa soil

Average gain or loss of nitrogen in pounds per acre

Year	Maize	Barley	Kerao (Pisum arvense)
1930-31	+107·2±24·4	+86·75±44·02	+105·00±61·67
1931-32	—9·4±15·4	—29·50±28·47	+124·75±15·03
1932-33	—48·3±24·1	—35·25±15·68	+29·50±25·02
1933-34	+54·1±15·1	+24·00±18·74	+94·75±26·20
1934-35	+96·1±16·1	+13·50±21·77	+33·50±42·25

Significant gains of nitrogen by the soil are observed after a maize crop. The gain in nitrogen might be due either to the effect of the secretions of maize roots on the nitrogen-fixing flora in the soil or to a specific organism in the maize roots or to both. Laboratory experiments show that it may be due to both. Maize root washings alone increased the nitrogen-fixing power of the soil flora by 15·56 per cent, and an organism isolated from the maize roots was able to fix two to three milligrammes of nitrogen per 100 c. cm. of mannite solution. These experiments could not be continued at Pusa owing to the earthquake and the subsequent transfer of the Institute. At Delhi the field and laboratory experiments were resumed during the year. It will be some time before the results of field trials will become available. The laboratory experiments confirmed the previous results and, in addition, showed that when sterilized maize seeds were grown in an atmosphere free of combined nitrogen, the seedlings utilized atmospheric nitrogen which was to the extent of two-thirds of the total nitrogen in the seedlings. The evidence strongly suggests that, contrary to the previous views, the maize plant is able to fix atmospheric nitrogen. More and rigorous laboratory and field tests are necessary to establish it beyond doubt and also to understand clearly the mechanism of fixation, and these experiments are in progress.

5. Manuring for increased yields

It is necessary and it is possible to increase the yield of crops per acre. There is as yet no danger of overproduction, and what appears to be overproduction is really the result of inadequate distribution. As efficiency in production increases and cost decreases, areas less suitable for the growth of a given crop will eliminate themselves, leading to a rational geographic redistribution of crops.

It has been seen in the discussion on soil problems that the problem of increase in yield per acre is linked up with soil fertility which is the expression of proper soil management and fertilizer practice. Improved implements of tillage can do a little in increasing yields, though not always and on all soils ; improved and high-yielding varieties can do a little more. The total improvement, however, by these means is small compared to the improvement brought about by the use of manures and fertilizers. The next step in advance should be towards increasing the efficiency of fertilizers and manures. The mechanism of retention and the extent of depletion of fertilizer constituents and the displacement by the latter of trace elements which are necessary for plant growth depends on the chemical nature of clay minerals. It is therefore evident that soil science problems and fertilizer problems cannot be separated as was done in the past.

With the understanding of the significance of the major elements—nitrogen, phosphorous and potassium—in crop nutrition and with the experience gained through three decades in the field and in the laboratory, the scientific investigator and the practical agriculturist have begun to realise the scope and limitations in the use of artificial fertilizers in Indian soils, and a justifiable bias in favour of organic manures has developed. The use of organic manure is necessary both to increase nitrogen and humus in soils.

In practice, however, this wholesome bias is being applied by the cultivator in a manner detrimental to food crop production. The cultivator gets more money value from crops like sugarcane, cotton, tobacco, jute and betel-leaf than what he can obtain by the sale of food crops. He, therefore, reserves his best lands for money crops and also manures them with his cattle manure at the expense of food crops. This and the adoption of unsound rotations lower the quantity and quality of food crops on those lands which are already of relatively low fertility and, thus, the original differences between the good and poor blocks of land is gradually exaggerated and food crop production falls to its basic minimum. This practice should be altered, and the alteration will probably depend upon the diversion of part of the supply of organic manures and crop residues, from money crop lands, to the relatively poor food crop soils, and make up deficiencies in plant food by the use of appropriate fertilisers. The results of experiments with fertilizers and manures have already been discussed under crop husbandry. But a permanent solution to the problem lies in the study of the theory and practice of mixed farming and its establishment on a scientific basis. These studies have been taken up at Delhi and will naturally include disposal of crop residues and other farm wastes in a manner which will easily fit into the cultivator's routine.

6. Agriculture in relation to National Nutrition and Health

A recent but a very important development is the world wide interest in problems of nutrition. Without adequate food and better nutrition, hygiene alone is not enough to maintain efficiency in work and to check ravages of disease. The country must produce enough food of suitable nutritive quality. Agriculture is, therefore, at the back of the whole problem.

The practical questions for consideration from the point of view of farming are—

(1) to know what should be grown for food ;

(2) to investigate the means of producing those food crops in sufficient quantity and with the highest possible nutritive and health giving properties.

The answer to the first point will be provided by the nutrition expert, and the answer to the second will have to be found by the agricultural scientist. The next few years will probably see a considerable change in our ideas on crop planning and crop production from the nutrition point of view. Suggestions from the nutrition expert in regard to alterations in the existing cropping systems will have to be investigated, whether the alternative cropping will be suitable to the soil conditions and climate of the locality. Investigations are necessary to ascertain whether breeding for high yields can be associated with the highest nutrition per acre. The health units in many plant foods are in the periphery of the product. The maximum of periphery per acre is not always obtained by crops giving the maximum yield per acre. What little evidence there is, indicates that in crop breeding maximum yield is not associated with maximum protein content, and that on the other hand the tendency is to operate in the reverse direction.

Recent work has shown that soil conditions and manurial treatment can influence plant metabolism and protein make-up, with the result that the nutritive value of crops varies with the nutritional factors available to the plant. The relative nutritive value of wheat (Pusa 52, 1937 crop) grown under different manurial treatments was investigated during the year. The total nett protein value, which is of the utmost importance in judging the relative nutritive values, establishes the decided superiority of the grain raised with cattle manure over grain raised with mineral fertilizers or with no manure.

Wheat grain raised with	Protein content of grain	D. C. Digestibility co-efficient	B. V. Biological value	N. P. V. Nett protein value
	%	%	%	%
Cattle manure . . .	17·76	94·54	85·09	14·29
Mineral fertilizers . . .	16·98	90·35	81·48	12·56
No manure	17·44	91·32	84·04	13·39

These results further confirm the previous findings that the type of manuring not only influences the growth and yield of crop but also its protein make-up and nutritive value. These results further strengthen the connection between soil fertility and nutritive value of the crop.

This discovery has opened up a wide field for investigation which is of utmost importance to national nutrition. The agricultural scientist is responsible to lay down a rational policy of manuring. Investigations are necessary to ascertain the best ratios in which organic manures and chemical fertilizers should be used to the best advantage to secure optimum yield and nutritive value in the resulting crop.

7. Quality in Crops

Another significant development affecting the cultivator is in regard to certain specific qualities and standards demanded by the trades and industries which employ the agricultural produce. As examples may be cited milling and baking qualities in wheat, malting qualities in barley, qualities for cigar, cigarette and chewing purposes in tobacco, and qualities for *gur* and sugar manufacture in sugarcane and sugar-beet. Investigations have shown that, apart from varietal differences, the conditions of soil and fertilizer treatment also affect appreciably the quality of the produce. The effect of manures and fertilizers on the quality of tobacco have been under study at Guntur. The effect of manurial applications was visible in the total number of leaves and the rate of maturity. Farmyard manure and superphosphate induce early maturity of the leaf. Samples of cured leaf when submitted to quality tests by experts evoked conflicting valuations, the greatest agreement being with regard to the better quality of the leaf from unmanured and farmyard manured plots.

The problem of colour development by certain sugarcane juices was under study. The colour appears to be due to the presence of certain soluble nitrogenous bodies, especially asparagin and aspartic acid. The elimination of these bodies by activated paddy husk carbon is not complete, and so they escape into the juice and finally impart colour to the *gur*. The effect of iron greening tannins on colour production was also under study. The tannins, which belong to the group of polyphenols, are present in sugarcane in such small quantities as 0·01 to 0·02 per cent on juice, and these are present mostly in the assimilating parts of the cane. Experiments are in progress to devise a simple method of eliminating these colour-imparting bodies from sugarcane juices.

On the factory side, coloured canes are long known to give trouble in clarification by the sulphitation process, yielding brown-coloured sugars. The pigments of the rind, which consist mostly of anthocyanins, have been investigated for their properties, especially those fractions which contaminate sugar crystals produced by the sulphitation process, as also the possibilities of their elimination by oxidation, reduction and absorption methods. These investigations have led to the development of a workable method, which can be employed on the factory scale, to eliminate the colouring matter of canes with coloured rind.

8. Utilisation of Agricultural Produce and Waste

Agricultural research does not end with the study of the problems concerned in the raising, harvesting and storage of crops. The study of technical and economic questions involved in the use of agricultural produce and wastes is of considerable importance in the economic development of agriculture and in raising the standard of living of the cultivator. Every bit of agricultural produce grown on the farm should be considered as potentially valuable either as food or as raw material for industry.

Investigations on the conversion of paddy husk into active carbon and its use in *gur* and sugar manufacture by the open pan process were pursued during the year. The cost of producing carbon is still further reduced (from As. 4 to As. 1½ per pound) by effecting simple improvements in furnaces for

the more economic utilisation of heat and by reduction in the amount of caustic soda. These appreciably reduced the cost of production. Similar improvements were also made in the treatment of juice for *gur* manufacture with the aid of the active carbon. Besides testing and advising on the samples of carbon prepared by others in different parts of the country, guidance was given in the working of a centre for making large quantities of active carbon opened near Saharanpur by the Department of Industries in the United Provinces.

At Guntur and Pusa, experiments were carried out to find out cheap suitable substitutes for coal which is used in the flue-curing process as developed by the Institute. Steam coal can be easily substituted in the several stages of the process up to the fixing stage with any fuel like dry leaves, ground-nut husk, stalks of grain and cotton. This means an appreciable reduction in the cost of curing tobacco.

9. Pests and Diseases of Crops

Improvements in agriculture by the introduction of new and better varieties of crops, better rotations and better methods of cultural and manurial practices are not unmixed blessings. These improvements encourage the development of the existing crop pests and diseases and attract new ones. It is one thing to grow better and more crops, and it is another to gather the harvest in full. It is relatively easier to grow a perfect crop than to protect it from damage by insects and disease. The case of sugarcane is an example. The rapid spread of heavy-yielding varieties of sugarcane has provided a larger and more continuous supply of food material for insect pests and diseases. *Pyrilla* has broken out in epidemic form twice in less than half a dozen years, and damage by borers has become a major problem.

Immense damage is caused to crops by insect pests and fungal diseases. The attack by insects makes the plant liable to secondary infection from fungus or bacteria or virus, or all of them. Methods of control such as spraying and dusting are usually uneconomical for agricultural crops, but are often financially possible in the case of plantation estates and horticultural areas. A further measure of control is the biological control in which insect pests are checked by encouraging the development of parasites and predators which feed on insect pests. Any method of control depends for its success on previous investigations on the life-history, habits, vulnerable points in life-history and mode of attack on the plant by the insect pest.

Among such investigations, ecological studies—studies on living organisms in their own environment among friends, competitors and foes—offer a new and promising field for the investigation. A knowledge of the response of insects to temperature, humidity, light and other environmental factors would be of value in assessing the potentialities of a pest or its parasites and predators, in defining the climatic zones and bars and in forecasting outbreaks of insect pests.

Plant diseases have a variety of origins. The bulk of them are due to fungi and bacteria, and in recent years a large number of virus diseases which are directly transmitted by sucking and biting insects have come into prominence. The study of plant diseases with reference to their life-histories and development is a necessary preliminary to devising methods of control

such as spraying and seed treatment, but these are not always economically possible. Surveys of the more important diseases and breeding and testing of crops for disease resistance are the directions in which practical control methods are sought.

Sugarcane pests.—Work on the subject was continued under a Scheme financed by the Imperial Council of Agricultural Research. During the year under report intensive studies were carried out at New Delhi and at the Substations at Karnal, Pusa and Coimbatore on the seasonal incidence of borers on sugarcane, and valuable data were obtained on the habits of the pests and of the parasites. At Karnal the work was of a more intensive character and included observations on the seasonal incidence of the major pests on four varieties of sugarcane, *viz.*, Co. 285, Co. 312, Co. 313 and Co. 331, under carefully laid out and controlled experimental conditions.

The top-borer of sugarcane (*Scirpophaga nivella*) commenced its activity about the middle of July and continued up to the time of harvest. All the varieties tested were heavily attacked by this borer except Co. 331 on which it was significantly less than on other varieties. The damage by the stem-borer (*Diatræa sticticraspis*) increased rapidly in all the varieties tested up to the third week of June, after which there was a steady fall and was practically nothing in the third week of July. The pest did very little damage to the stalks and differences due to variety were insignificant.

The damage caused by the root-borer (*Emmalocera depressella*) was the same in all the varieties in the initial stages of their growth and reached the maximum in the first week of June and was practically *nil* in the third week of July. In August it again increased and there appears to be no appreciable difference in the resisting capacity of the various varieties to this borer.

At the time of harvest the percentage of root-borer was significantly more in the case of Co. 331. In the periodical observation plots and in the final observation plots, there were termite attacks on the roots in all the varieties to nearly the same extent.

A preliminary experiment was carried out at Cuttack on the effect of *Trichogramma* parasite in the control of damage by the stem-borer which appears to be the chief borer pest of Orissa. Judging from the counts of "dead-hearts" the *Trichogramma* distributed block contained less "dead-hearts" than in the control block. The percentage of stem-borer in the stalks examined at harvest time indicated that *Trichogramma* was effective in checking the progress of the stem-borer.

Pests of cotton.—Ecological studies of spotted boll-worms which are pests on cotton and their important parasites were in progress during the year. The fecundity and development of *Earias fabia* and its parasites *Microbracon lefroyi* and *Melcha nursei* were studied at temperatures of 16°C. and 20°C. with saturation deficiencies of 0, 3 and 9 mm. The spotted boll-worm appears to be affected considerably by humidity and temperature. Moist conditions within certain limits increase the reproductive powers while dry conditions retard it. At 20°C. the incubation, larval and pupal periods are nearly half than at 16°C. When temperature is kept constant, the rate of development is quickest at a saturation deficiency of 3 mm. and the threshold of development lies between 10°C. and 13°C. *Microbracon lefroyi* parasite on the spotted boll-worm develops more quickly than the host, and in regard to moisture

the optimum condition for the parasite development was found to be a saturation deficiency of 0 mm. or saturated atmosphere, as against one of 3 mm. for the host. The rate of development of the other parasite *Melcha nursei* is comparatively slower than of *Microbracon lefroyi*, but is still faster than that of the host.

Insect vectors of tobacco leaf-curl.—Preliminary investigations in the past year indicated that sann-hemp was an alternate host of leaf-curl virus, and that the white-fly *Bemisia gossypiperda* could transmit the disease from sann-hemp to tobacco. Investigations were carried out to ascertain if the white-fly could also transmit the disease from tobacco back to healthy sann-hemp and from tobacco to tobacco and sann-hemp to sann-hemp. It was observed that the common weed *Ageratum conyzoides* also has a leaf-curl disease at Pusa and is a host of the white-fly. This weed was also included in the experiments to determine if this plant like sann-hemp is also a host of leaf-curl virus, and if so, the part played by the white-fly in the transmission of the virus.

The white-fly has been found to be an important vector of leaf-curl of tobacco for all the five types of the viruses. Sann-hemp has been found definitely to be an alternate host of the tobacco leaf-curl viruses A and X, the two viruses causing different symptoms in sann-hemp giving rise to two types of disease which have been designated SV 1 and SV 2. The white-fly can easily transmit both types of disease from sann-hemp to tobacco. As the tobacco and sann-hemp seasons overlap in North Bihar, sann-hemp is an important source of the infection for tobacco.

The white-fly can transmit leaf-curl from tobacco back to sann-hemp but it does not appear to be a very efficient vector in this respect. In nature leaf-curl appears in sann-hemp in July. Seeing that leaf-curl in North Bihar does not appear in tobacco before about the middle of September, leaf-curl affected tobacco does not appear to be responsible as an important source of infection for this disease in sann-hemp. In the case of weed *Ageratum*, which is also an alternate host of tobacco leaf-curl, especially of D type, white-fly can easily transmit disease from this host to tobacco and it also can transmit easily from tobacco back to the weed. In some experiments one hundred per cent positive transmissions were obtained. The weed *Ageratum*, which is perennial in North Bihar, is thus an important source of infection of leaf-curl of D type virus of tobacco and can easily get the disease back from the crop. The white-fly is capable also of easily transmitting the disease from sann-hemp to *Ageratum* though the transmission back to sann-hemp does not appear to be common. The white-fly can transmit the disease from tobacco to tobacco, but it does not appear that it could do so in all cases. It would, therefore, appear that in nature or under farming conditions in North Bihar the tobacco which is affected with the disease does not seem to be an important source for the healthy tobacco, and that the alternate hosts sann-hemp and *Ageratum* seem to play a much more part in this connection. These two hosts harbour leaf-curl viruses A, D and X types. The alternate host, if any, for B and C types yet remains to be discovered.

No exact experiments to determine the length of time necessary for the white-fly to feed on the host for the successful transmission of the disease to a healthy host have been carried out, but it may be said that a period of five to six hours, which constitute the limit to which white-fly fed on plants, was

enough to trasmit the disease. Feeding for shorter periods has not been tested. Besides sann-hemp and *Ageratum*, it was observed that the white-fly would freely breed on a number of other plant hosts some of which show leaf-curl closely allied to, if not identical with, tobacco leaf-curl. It would, therefore, appear that, unlike many viruses, the tobacco leaf-curl virus may have a big host range which makes the problem of the control of the disease by the eradication of the host plants very difficult, and the chances of success by keeping the white-fly under check by direct control methods appear to be greater.

Experiments were carried out at Pusa to find out a method of artificially transmitting leaf-curl disease of tobacco. Non-viruliferous white-flies were fed on juice obtained from a virus-affected plant. These flies were later placed on tobacco seedlings raised in an insect-proof cage. Of about 110 treated, two showed very clear symptoms of a mixed type of leaf-curl, five showed slight vein-clearing and others were not affected at all.

Pests of fruits and vegetables.—The survey of codling moth was started in 1937 and was completed during the year under report. The study revealed that codling moth is widely distributed in Baluchistan and constitutes a major pest in that province. It is becoming serious every year, and during last summer 50-85 per cent of apple fruits were found infested and damaged by this pest. The larvae of *Spilonota ocellana* damage principally the leaf and flower-buds of apple but they do not bore into the fruit, as is done by the codling moth larvae. The larvae of *Euzophera punicella* are liable to be confused with the larvae of codling moth. The former are sometimes found in large numbers inside the fruits but they do not appear to attack sound fruits. It would appear probable that codling moth was and is being introduced into India through infested apples imported from Afghanistan.

The incidence and bionomics of the fruit-fly *Chaetodacus ferrugineus*, which is a serious pest in the North-West Frontier Province, was further investigated. This pest is active in the Peshawar District between July and September and is disastrous to late varieties of peach and pear ; in Kohat District it does considerable damage also to loquat and guava and other fruits ; it damages peaches and pears at Parachinar from mid-August to October. At Kohat the effect of various baits and poisonous sprays on the fruit-fly was also studied. *Citronella* bait attracted the largest number of flies but the attraction was limited to male flies. *Pollard* baits, the ingredients for which are easily available in villages, were effective. Sodium fluosilicate spray proved ineffective. A cheap trap costing two annas and a half was devised.

Insecticides.—The efficiency of some insecticides was tested under different conditions against certain pests. Lead arsenate sprays at 2 lb. in 100 gallons of water, sodium fluosilicate bait at one part of fluosilicate to 50 parts of bran and two parts of *gur* by weight, and sodium fluosilicate and lime dusts in the proportion of 1 : 4 proved unsuccessful against hoppers and adults of *Poecilocerus pictus* on brinjal plants. Sodium arsenite spray killed 33 per cent of the hoppers on the first day of application and the remainder died in the next three days. A poison bait containing sodium fluosilicate proved highly effective against crickets (*Gryllus domesticus*) damaging artificial silk in a textile mill at Amritsar. A mixture of Paris Green and wood-ash dusted on *cucurbit* crops proved effective against the pumpkin beetle. Thallium sulphate as a poison bait for ants was attractive to *Camponotus compressus*,

Monomorium spp. and a few other species of ants, when freshly made, but as the bait became stale, its attractiveness decreased.

Sugarcane diseases.—The investigation of sugarcane diseases was continued during the year under a Scheme financed by the Imperial Council of Agricultural Research. The scheme originally started in 1933 for the investigation of the mosaic disease of sugarcane and subsequently its scope was extended to studies of all sugarcane diseases.

Repeated experiments over a number of years with Co. 213 to find the effect of mosaic on yield and juice of sugarcane, have conclusively shown that this widely grown cane, though susceptible to mosaic, is highly tolerant, that is, even a very high infection does not reduce the yield of stripped cane by more than 10-15 per cent., while no significant differences between sucrose, brix, purity and glucose of healthy and mosaic cane was observed. These findings indicate to some extent that there need be no apprehension regarding mosaic disease on cane in view of the experience of those tropical cane-growing countries where the disease was found capable of causing great reductions in yield and deterioration of the juice.

Investigations of the properties of mosaic virus have shown the existence of marked seasonal influence on successful transmission of mosaic, the period of May and June giving heaviest infection. On the basis of thermal death-point, there appears to be more than one strain of mosaic. Inoculation experiments have shown that mosaic sugarcane leaf-juice can, on inoculation, reproduce disease in maize and sorghum. There is as yet no evidence that mosaic in India is transferred from plant to plant in the field by insect agencies. Cases of natural transmission were, however, observed at Gurdaspur, Jullundur and Lyallpur in Northern India and at Coimbatore in Southern India.

Studies on the phenomenon of recovery from mosaic indicate that sugarcane mosaic virus does not appear to be evenly distributed within the cane, as all the setts from a mosaic-infected cane do not give rise to diseased plants. Possible control methods are in the direction of rogueing and the use of healthy setts for propagation. In the direction of control through varietal resistance experiments are in progress for measuring relative resistance to mosaic by artificial inoculation.

The question of the existence of the " cyclostage " organisms in the tissues of mosaic-infected canes was carefully investigated by Dr. Padwick in the Mycology Section and Messrs. Joshi and Datta in the micro-biological laboratory. Dr. Desai of this Institute reported in 1932 the isolation from mosaic-infected canes an organism capable of passing through an L_3 Chamberland filter candle. The organism has been reported to have a filterable stage and a bacterial stage, the latter being of a shorter duration than the former. Attempts to repeat the work on filterability made during the previous two years were however unsuccessful. The investigation was, therefore, repeated in the two laboratories to find out if an organism, or organisms, having cyclostage could be isolated from mosaic-affected sugarcane tissue. The constant failure indicated that in some way the filtering technique employed might be responsible. The candles used are usually tested by passing air into them under water and observing the pressure at which bubbles of air arise from the pores of the candle. Those candles which bubbled at 18 to

22 lb. pressure are accepted. This is a method commonly employed in work with Chamberland filter candles. With the later consignments of candles used since 1936 the method of testing was different, having been based on the rate of flow of a known quantity of water through the candles under constant pressure. These candles were found not to bubble until about 24 lb. pressure. Thus by the different methods of testing the candles, a denser grade of candle was selected and this might be the explanation for the difference in results obtained at different times with regard to the filterability of the organisms.

Apart from tracing the failure to obtain isolations to the candles and the methods employed, the original findings of Dr. Desai, *viz.*, the isolation of an organism with cyclostage, was confirmed. Using candles which allowed air bubbles between 18-22 pounds pressure, organisms with cyclostage as described by Dr. Desai were isolated from mosaic-affected sugarcane tissue and leaf. The investigation also brought to light the interesting fact that the organism could be isolated only from samples drawn between mid-March and mid-June which corresponds to the period when the sugarcane crop is two to four months old. This finding is in agreement with the results of direct inoculation experiments in which optimum infection from mosaic virus inoculation into sugarcane could be obtained between the months of March and mid-May, and this period tallies with the period in which cultures of organisms are obtained from mosaic-affected leaf juices.

In regard to other diseases, red-rot and *Striga* have been observed to be doing damage in the Punjab and *Striga* in the Hyderabad State. Diseases new to India have also been observed. The disease known as top-rot, called "Pokkah Boeng" in Java, has recently been found and appears to be on the increase. It is especially prevalent in the Punjab and Bihar. Cane mildew common in many cane-growing areas was observed to be attacking Co. 515 at Shahjahanpur. Red Stripe, a bacterial disease, reported for the first time in India in 1932, occurs throughout India. At Dacca and Sepaya as many as eighty per cent of the plants of cane were affected.

The practical problems for attention are a survey of diseases for study of the development of disease, testing varieties for resistance to disease, and the study of physiologic forms. The last is the most important work of a fundamental nature since adequate testing is dependent on the knowledge of these.

Cultural methods for disease control.—Certain fungus diseases are either encouraged or controlled by agricultural practices. The *bunt* disease of wheat is one of them. It is a soil-borne as well as a seed-borne disease. It was observed in the previous year that one year's rotation involving freedom from wheat was not enough to prevent the disease. The observation was extended to the year under report, and it would appear that a period of two years of freedom from wheat reduced soil infection considerably. Excess of irrigation would appear to encourage the disease.

Testing crops for disease resistance.—The introduction of varieties of crops which are proved to resist disease is a simpler and more economic method of disease control than curative methods. Varieties of crops produced by the plant-breeder are tested for rusts, smuts and virus diseases before they are multiplied for distribution.

Forty varieties of wheats were tested for resistance against loose smut disease of wheat. Seven varieties were found to be immune, nine highly resistant. The remaining were susceptible to infection ranging from 30 per cent to 81 per cent.

Relative to the testing of varieties, the fungus of the genus *Fusarium* has been under study. In 1926 Dr. Butler came to the conclusion that the *Fusarium* fungus causing wilt of pigeon-pea (*Cajanus indicus*) is indistinguishable from that which causes wilt of *til* (*Sesamum indicum*) and cotton (*Gossypium herbaceum*), and should be considered as *Fusarium vasinfectum*. Later investigations at this Institute on the wilt disease of sann-hemp showed it to be due to *Fusarium vasinfectum*. In the later experiments in 1934, diseased material from the previous year's infected plants was used as inoculum, and it appeared that the sann-hemp organism could infect pigeon-pea quite readily and *vice versa*, but that neither of these strains could infect cotton or *Sesamum*. Other workers in Bombay failed to substantiate the findings. In an attempt to straighten out what is admittedly a confusion, several distinct species of *Fusarium* have been isolated and are under study. A great deal of work has been done at this Institute in the selection of varieties of pigeon-pea resistant to wilt. Similarly elsewhere there is selection of cotton for resistance to wilt. If it is not established that the strain of *Fusarium* which attacks pigeon-pea is the one which attacks sann-hemp, it is clear that the basis for selecting resistant varieties within a species is not sound. Consequently, for guidance in the study and selection for resistance, it is a problem of considerable importance to settle the question as to which organisms are responsible for wilts in the various crops.

III. GENERAL ADMINISTRATION

Charge.—Rao Bahadur B. Viswa Nath continued to officiate as Director of the Institute throughout the year. During the period of leave of Mr. Wynne Sayer from 28th May, 1937 to 26th October, 1937, the post of Joint Director was held by Dr. Hem Singh Pruthi, Imperial Entomologist.

Honours.—Two officers of the Institute received distinctions during the year. Rao Bahadur Venkatraman, Sugarcane Expert, was elected President of the Agricultural Section of the Jubilee Session of the Indian Science Congress held in Calcutta in January 1938, and Mr. Kashi Ram, Assistant Economic Botanist, was awarded the title of Rai Sahib on New Year's Day.

Staff.—Dr. Mitra continued to hold charge of the Mycological Section upto 14th November, 1937, when the post of Imperial Mycologist was filled by the appointment of Dr. G. Watts Padwick who assumed charge with effect from 15th November, 1937.

During the absence on leave of Mr. Wynne Sayer, Mr. Arjan Singh continued to hold charge of the Agricultural Section upto 26th October, 1937.

The Chemical, the Entomological and the Botanical Sections remained throughout the year in charge of their permanent Heads, *viz.*, Rao Bahadur B. Viswa Nath, Dr. H. S. Pruthi and Dr. B. P. Pal.

Mr. K. Krishnamurthi Rao, Assistant Sugarcane Expert, retired on superannuation towards the end of the year after over 30 years of service, a quarter century of which was at the Sugarcane Station, Coimbatore. I wish to place on record the good services rendered by this officer, particularly during the long probationary period of the Station.

Schemes of Research financed by the Imperial Council of Agricultural Research.—The nine schemes mentioned in last year's report continued to be in operation during the year. The one for breeding rust-resistant wheats was extended for a further term of 3 years from April 1938, and the breeding work was transferred from the Rust Research Laboratory to the Potato-breeding Sub-station at Simla. Besides, the Imperial Council of Agricultural Research made a grant of Rs. 5,000 to the Institute for carrying out a survey of the various fruit-growing tracts of Baluchistan to determine the distribution and status as pests of Codling Moth and *Spilonata ocellana*. A report of the survey has been made to the Council, and a detailed account has been submitted for publication in the *Indian Journal of Agricultural Science*. The following work was also carried out at this Institute in connection with enquiries initiated by the Research Council :—

(*a*) Analysis of samples of soils collected by the Special Officer appointed by the Council for the Clove Inquiry.

(*b*) Analysis of soils collected in connection with the Cinchona Inquiry.

(*c*) Collection of data in connection with the establishment of pedigree herd books for dairy cattle in India.

Training.—For the post-graduate courses commencing in November 1937, fifty-two candidates applied for admission, of whom 33 were recommended by the Provincial authorities. Sixteen applicants were selected for admission—four in Botany, three in Agricultural Chemistry, two in Entomology, two in Mycology and five in General Agriculture. Of these, one in Entomology left soon after admission and one in Agricultural Chemistry left after 10 months on getting appointments.

During the year under report ten post-graduate students successfully completed the two-year course and qualified for the Institute Diploma : four in Botany, three in Agricultural Chemistry, one in Entomology, one in Mycology and one in Sugarcane Breeding. Three students completed the one-year course in farm organisation and general farm engineering.

In addition, one employee of the Assam Government, one of the Indore State and two private candidates were admitted for short course training in particular subjects.

The special course in flue-curing of tobacco was attended by seven candidates : two from the United Provinces Agricultural Department, one from the Madras Agricultural Department, one from the Sind Agricultural Department, one from Baroda State and two private candidates from the United Provinces.

Eight honorary research workers were afforded facilities for carrying out a definite piece of work—four in Chemistry, two in Entomology and two in Mycology.

Library.—The total number of publications received in the Library both by way of exchange and by purchase was 3,013. Over 2,300 books were issued out on loan, of which 300 were sent out to the scientific workers in the Provinces and Universities.

Visitors.—The year was marked by an influx of distinguished visitors from different parts of India and abroad, of whom special mention may be made of a number of scientists from Great Britain and other countries who

came out to India to attend the Jubilee Session of the Indian Science Congress held in Calcutta in January 1938. The visit was of great value in that the workers at the Institute came into personal contact with the workers abroad. His Highness the Sultan of Muscat also visited the Institute.

IV. ACCOUNTS

The total expenditure of the Institute and its sub-stations at Karnal and Coimbatore during the financial year ended 31st March 1938 amounted to Rs. 7,38,074.

Name of establishment	Expenditure Rs.
General expenditure of the Institute including the office of the Director, Irrigation, Power Supply, Gas Plant and the Estate Establishment	2,11,680
Agricultural Section	1,33,874
Botanical Section	44,902
Chemical Section	71,867
Entomological Section	66,199
Mycological Section	37,892
Agricultural Sub-station, Karnal	66,517
Sugarcane Station, Coimbatore	92,306
Petty Construction	12,837
	7,38,074

The expenditure of the various research schemes financed by the Imperial Council of Agricultural Research amounted to Rs. 1,47,207 as shown below which was met from the funds provided by the Council :—

	Expenditure Rs.
(*a*) Research on Mosaic and other Diseases of Sugarcane	18,857
(*b*) Research on Insect Pests of Sugarcane	17,429
(*c*) Research on Chemistry of Sugarcane	2,182
(*d*) Scheme for Analysis of Soil Samples	300
(*e*) Scheme of Pedigree Herd Book —Sahiwal Breed	396
(*f*) Research on Genetics of Sugarcane, Coimbatore	7,543
(*g*) Sugarcane Sub-station, Karnal	13,104
(*h*) Tobacco Breeding Sub-station, Guntur	13,944
(*i*) Potato Breeding Sub-station, Simla	43,307
(*j*) Botanical Sub-station, Pusa	24,885
(*k*) Scheme for Survey of Fruit-growing Tracts in Baluchistan	5,260
	1,47,207

The receipts of the Institute and its sub-stations amounted to :—

	Rs.
Main Institute	25,063
Agricultural Sub-station, Karnal	37,964
Sugarcane Station, Coimbatore	10,190
	73,217

REPORT OF THE IMPERIAL AGRICULTURIST

(Wynne Sayer)

INTRODUCTION

The Agricultural Section is one of the major sections of the Imperial Agricultural Research Institute. It consists of the main Agricultural Farm at New Delhi with the Statistical Branch of the Institute attached to it and the Agricultural Sub-station at Karnal. On both these stations cattle-breeding operations are carried on along with agricultural work on the well-known principles of mixed farming. A pedigree herd of Sahiwal cattle is maintained at New Delhi, and a similar herd of Tharparkar cattle at Karnal. The chief functions of the Section are to provide full facilities to other Sections of the Institute for their research work in the fields, to test the results of their researches on a field scale, to multiply seeds of improved varieties of crops produced by selection and breeding and to distribute them to Provincial Agricultural Departments and private individuals all over India. Agricultural experiments on different grain, fodder and revenue crops, manurial and cultural experiments, and testing of machinery and implements of all-India importance are also carried out on a large scale, while from the two pedigree herds of cattle, bulls are distributed all over India and breeding and inheritance problems in general are studied.

1. AGRICULTURAL SECTION, NEW DELHI

I. ADMINISTRATION

Mr. Wynne Sayer, Imperial Agriculturist, held charge of the Agricultural Section with the exception of the period of his leave from 28th May to 26th October, 1937, when Mr. Arjan Singh, Assistant Agriculturist, was in charge of the Section in addition to his own duties.

II. TRAINING AND ADVISORY

Messrs. Y. C. Gupta (U. P.), N. Ahmed (Assam) and Fazal Karim (Punjab) completed their year of post-graduate training in farm organisation, farm management and general farm engineering on 31st October, 1937.

Messrs. K. H. Sujansingani (Sind), Aijaz Husain (U. P.), Biswanath Das (Orissa), Sardar Mohamad (Punjab) and Atar Singh (U. P.) were admitted for one year's post-graduate training from 1st November, 1937. Mr. P. L. Kohli (N.-W. F. P.), after completing one year's training at Coimbatore, joined this Section on 1st November, 1937 for his second year's study in sugarcane research.

The following staff attended the short course in milking and handling of cows, calf-rearing and cattle managment :—

1. Mr. Md. Ismail, Dairy Manager, Allahdad Cattle Farm, Multan.
2. Mr. Premsukh, Fieldman, Government Cattle Farm, Manjhara (U. P.).

PLATE I

PLAN OF AGRICULTURAL SECTION

OF

IMPERIAL AGRICULTURAL RESEARCH INSTITUTE

NEW DELHI

—Scale 16" = A Mile—

3. Mr. B. L. Dutt, Dairy Supervisor, Government Cattle Farm, Hissar.
4. Lalji, Head Gowala, Allahabad Agricultural Institute, Allahabad.
5. Mangal Singh, Head Gowala, Imperial Dairy Institute, Bangalore.

Advice to various private individuals and Government officers was given by correspondence, direct or through the Director of the Institute. The important subjects dealt with are cattle breeding, irrigation engineering, cultivation of berseem, motor tractors, green fodders, poisonous grasses, pasture grasses, source of supply of seeds of improved varieties of crops, manuring of sugarcane, source of supply of improved implements, short-planting of sugarcane, soy-bean cultivation, method of making compost manure, suitable crops for green-manuring, etc.

III. GENERAL FARMING

1. Soil Fertility

With the completion of the layout and levelling of the Top Block in the Delhi Farm, we have 380 acres net area available for crop cultivation as follows :—

	Acres.
Main Block	263·55
Middle Block	43·90
Sewage Block	22·00
Top Block	50·55
Total	380·00

From this area we have to meet the full demand of food and fodder for about 300 head of cattle (the Sahiwal herd and the work bullocks), and at the same time the soil has to be conditioned and the fertility maintained and improved to bring it to a level of uniformity for experiments.

It is necessary here to explain that the entire area of 380 acres has been laid out and levelled according to a definite plan drawn up in 1935. In some cases this has meant radical alterations to the top and sub-soil as steep gradients have had to be eliminated. In general, the area has been dealt with severely —a necessary procedure owing to the considerable slope on which it was situated, and the fact that it was not laid out for flow irrigation. The results of this work will not be apparent for several years, but the whole operation has been necessary to make the farm what it now is, a perfectly laid out area suitable in all respects for work on irrigated and dry cropping on a large or small scale. The present treatment, rotational and manurial of each area, is based on the amount of levelling done and its apparent effect on the fertility of the land. Any form of permanent experiments has naturally to await the elimination of the more marked variations in the soil—a matter possibly of some years. We were very fortunate in being able to obtain the opinion of Professor R. A. Fisher, the eminent Statistician, on this point when he visited the farm, and his opinion was in full accordance with our policy.

Out of the above, an area of 22·95 acres in Shadipur plots A, B and C is devoted to sectional crops and miscellaneous experiments, and 43·90 acres in the Middle Block have been laid out for permanent manurial and other long-term experiments. The remaining 313·15 acres will be cultivated purely for the production of food and fodder on a mixed farming system for the study of rotations and their effect on fertility. The following rotations will be followed :—

Rotation No. 1—Main block—180 acres

Plot No.	Area in acres	*Kharif* (Summer)	*Rabi* (Winter)
1, 2 and 3 . .	45	Leguminous pulses such as *guar* (*C. psoralioides*) and cowpeas.	Oats
4, 5 and 6 . .	45	*Jowar* (*Sorghum vulgare*) for green fodder and silage.	Fallow
7, 8 and 9 . .	45	Cowpeas, *meth* (*P. aconitifolius*), soy-bean, *guar* and sann-hemp, all for seed	*Kharif* crops stand on
10, 11 and 12 . .	45	Green manure . . .	Oats

The soil of the above 180 acres is of a light type and was considerably weakened by intensive levelling. Every year one division of 45 acres will receive all the available farmyard manure at 300 maunds (one maund= 82·3 lb.) per acre.

Rotation No. 2—Main Block—60·60 acres

Plot No.	Area in acres	*Kharif*	*Rabi*		
13 and 14 . . .	29·85	*Jowar* . .	Gram		
15, 16, & 17 . .	30·75	Fallow . . .	Gram	15·75	Acres
			Berseem	15·00	,,

The soil of this area is heavy and has not been much disturbed by levelling. A dose of niciphos at one cwt. per acre to *jowar* will be applied, if necessary.

Rotation No. 3—Top Block—50·55 acres

Plot No.	Area in acres	*Kharif*	*Rabi*
1, 2, 3 and 5 . .	27·30	Early *jowar* . . .	Berseem
4 and 6 . . .	23·25	Pulses for grazing . .	Fallow

The soil of this block is of a very heavy type. Being situated on a steep slope, it has been subjected to very drastic levelling. The crops, except *jowar*, will be mostly grazed by the stock in the field.

Sewage Block—22 acres

The Sewage Block, which consists of an area of about 22 acres, of which about 14 acres are irrigated, and the remaining 8 unirrigated has been reserved for the utilisation of sludge and effluent, the products of the activated sludge plant. On the irrigated land, purely fodder crops, such as *jowar*, maize, oats and barley which can absorb large quantities of effluent, will be raised.

It will be seen from the above that along with the essential production of food and fodder for the livestock, ample arrangements have been made for the increase or maintenance of fertility of the soil by fallowing, green-manuring, application of organic manures and chemical fertilizers and the use of leguminous crops in the rotations.

2. Manuring

Farmyard manure.—Suitable pits were dug in which all the dung and litter from the cattle byres and paddocks were collected. The manure thus collected during the twelve months from October 1936 to November 1937 was used for manuring five acres of land at 400 maunds per acre, 50 acres at 300 maunds per acre, while the balance was utilised for the shade trees and grass plots on the roads. The total quantity of farmyard manure produced was 19,000 maunds with an average number of 80 work bullocks and 200 breeding herd stock of all ages. The manure was analysed in the Chemical Laboratory before applying to the fields. Its analysis is given below :—

	Per cent
Moisture	67·2
Organic nitrogen	0·62
Potash (K_2O)	0·569
Phosphoric acid (P_2O_5)	0·609

Compost.—Five pits were dug in different corners of the farm area, and all weeds and organic matter were collected in them for making compost manure which is expected to be ready for use soon after the monsoon season of 1938.

3. Season and Crops

Season.—The total rainfall during the year from June 1937 to May 1938 amounted to 20·30 inches.

The monsoon broke in the last week of June, the normal time for sowing *kharif* crops, and continued till the middle of July which enabled us to complete the sowing of all *kharif* crops successfully. There was then a complete drought till the middle of September, and crops were kept growing by means of irrigation. In the middle of September, a further 6 inches of rain fell which enabled us to prepare land and sow oats and gram without initial irrigation. A further 3 inches of rain fell in the month of January 1938 which proved very useful for cold weather crops.

Crops.—The statement given below shows the yields of crops grown on the farm during the year under report.

Statement of crop yields during 1937-38

Name of block	Plot No.	Crop and variety	Area in acres	Yield in maunds *		Average yield per acre at Pusa (last 5 years)
				Total	Average per acre	
						Mds.
Main Block	4	Berseem green fodder	15·00	5,466·80	364·45	294·34
Ditto	6	Ditto	12·74	6,438·70	505·39	
Ditto	14	Ditto	12·50	8,637·28	690·98	
Ditto	15	Ditto	4·51	1,194·53	264·86	
Ditto	7	Oats B. S. 1	15·00	408·20	27·21	15·03
Ditto	8	Ditto	15·00	434·83	28·99	
Ditto	9	Ditto	15·00	466·10	31·07	
Ditto	13	Ditto	15·00	418·28	27·89	
Ditto	16	Ditto	20·00	544·60	27·23	
Ditto	17	Ditto	6·25	175·08	28·01	
Middle Block	1 & 2	Ditto	23·90	537·78	22·50	
Sewage Block	...	Ditto	3·26	93·50	28·68	
Main Block	Shadipur C	Ditto	4·62	131·40	28·44	
Ditto	14	Oats B. S. 1 green fodder	0·35	134·85	385·29	
Ditto	10	Gram	14·50	198·53	13·69	7·66
Ditto	11	Ditto	15·00	154·38	10·29	
Ditto	12	Ditto	13·11	138·36	10·55	
Ditto	Shadipur B	Ditto	5·83	32·93	5·65	
Sewage Block	...	Ditto	6·00	20·00	3·33	
Main Block	5	Wheat P. 12	5·00	92·23	18·45	12·00
Ditto	5	Wheat P. 114	5·00	72·15	14·43	
Ditto	5	Wheat P. 165	5·00	83·63	16·73	
Middle Block	1	Wheat Miscellaneous varieties	0·90	24·25	26·94	
Sewage Block	...	Barley local, green fodder	1·58	340·05	21·52	
Ditto	...	Barley local	3·88	114·50	29·51	16·95
Ditto	...	Peas, Miscellaneous varieties.	6·51	97·65	15·00	9·37
Main Block	1	Maize No. 1	2·50	11·60	4·64	11·78
Ditto	1	Maize No. 2	2·50	14·08	5·63	
Ditto	1	Maize No. 3	2·50	14·50	5·80	
Ditto	14	Sugarcane, Miscellaneous varieties	1·22	444·75	364·55	
Ditto	1	*Jowar* local, green fodder	2·50	315·50	126·20	
Ditto	1	*Jowar* Malabar, green fodder	5·00	631·00	126·20	
Ditto	2	*Jowar* local, green fodder	15·00	2,019·95	134·66	
Ditto	3	Ditto	14·75	1,243·20	84·28	
Ditto	10	Ditto	14·50	2,446·93	168·75	
Ditto	11	Ditto	15·00	3,757·83	250·52	
Ditto	12	Ditto	14·11	3,374·53	239·16	

* 1 maund = 82·3 lb.

Total production on the farm during 1937-38

	Mds.
Grains—	
Maize	40·18
Oats	3,209·77
Wheat	272·26
Gram	544·20
Barley	114·50
Miscellaneous crops	132·16
	4,313·07
Green fodders—	
Berseem	21,737·31
Jowar	14,486·00
Miscellaneous crops	2,109·38
	38,332·69
Dry fodders	5,977·75
Sugarcane	444·75

This report mainly deals with our experiment to discover if our work on cereal crops and pulses could be continued from where we left it at Pusa or whether it all had to be discarded owing to soil and climatic differences.

Jowar.—This crop was grown for green fodder and silage: 43·61 acres were sown under this crop after berseem and 37·25 acres on oat stubbles with 10 maunds mustard oil-cake per acre as manure. The yield of green fodder was 219·7 maunds per acre in the former case and 113 maunds per acre in the latter.

Maize.—Three farm types of maize which used to give high yields of fodder and corn and always produced excellent silage at Pusa were grown here in plot No. 1 for cobs—2·5 acres under each type. From the low yield of grain it is evident that the soil here, if suitable, is not yet in high enough condition to grow maize.

Leguminous fodder crops.—The common pulses, *guar*, *meth*, cowpeas and soybean, which had established their value for feeding and grazing at Pusa, were grown in plots Nos. 4, 5 and 6 over a total area of 45 acres and seem quite suitable for Delhi conditions. The crop was grazed in the month of October and November before berseem was ready. These pulses were sown in drills and were intercultured constantly by bullock-hoes and thus stood well the two months' drought without irrigation.

Berseem.—The total area under berseem was 44·75 acres. It was sown from the first week of October and the crop was ready for the first cut early in December. The total outturn of green fodder was 21,737 maunds, *i.e.*, an average of 486 maunds per acre. The maximum yield was 691 maunds per acre from 12·5 acres in plot No. 14. After meeting the full requirements of feeding green, 5,009 maunds were available for making hay, of which 1,995 maunds were stored for feeding during the hot weather and rainy season.

A small area was kept for seed after taking two to three cuts of green fodder and about 4 maunds of good pure seed were threshed out from an area of 5·5 acres. The acclimatization of this crop and production of seed in India is a valuable achievement. It represents a factor of greatest importance for the future improvement of dairying and cattle-breeding in India. If progress continues like this and we can produce two to three maunds seed per acre, the whole question of seed production will be solved, as the threshing problem has already been overcome and any quantity can be handled with ease.

Oats.—The total area under oats for grain was 118·03 acres from which 3,209·77 maunds of grain was produced at an average of 27·19 maunds per acre. The maximum yield was 31·07 maunds per acre from an area of 15 acres in plot No. 9. This crop was sown under natural moisture without initial irrigation and was irrigated once in the whole season.

Wheat.—Three Pusa types of wheat, P. 12, P. 165 and P. 114, were grown in plot No. 5 on an area of 5 acres each. This crop was sown late after grazing off the pulse crop and irrigating the land. Three subsequent irrigations were given during the cold weather in addition to natural rainfall. The yields are given in the crop statement.

Gram.—This crop followed *jowar* which was grown in *kharif* and yielded low as compared with the last year's outturn owing to short rainfall in the winter and an attack of wilt in T. 17, T. 28 and P. F. 6 which were badly affected. This crop was not irrigated.

Sugarcane.—Seventy-five Co. sugarcane varieties were grown on the farm during the year, including Co. 441, Co. 442, Co. 443, Co. 444 and Co. 445 which were received in March 1937. The 15 varieties—Co. 437, Co. 440, Co. 520, Co. 521, Co. 522, Co. 523, Co. 524, Co. 525, Co. 527, Co. 528, Co. 529, Co. 530, Co. 531, Co. 532 and Co. 533—which were brought from Pusa in July 1937 and planted here, were killed by frost and no material could be obtained for fresh planting: those which yielded sufficient material were analysed in the Chemical Laboratory during the months of December, January, February and March. All the varieties thus analysed showed poor results in regard to sucrose content throughout the season. The only variety which went up to 18·10 per cent in March was Co. 313. Most of the heavy tonnage canes, except Co. 313 and Co. 421, showed poor sucrose content.

Percentage of sucrose content in juice of sugarcane varieties grown during 1937-38

Variety	December	January	February	March
Co. 213	7·44	6·38	7·34	14·77
Co. 313	12·64	12·25	15·12	18.10
Co. 331	6·49	10·74	11·98	15·97
Co. 336	7·22	7·40	10·72	12·38
Co. 344	9·52	11·54	13·33	14·50
Co. 347	7·33	9·14	10·10	13·80
Co. 348	5·59	7·68	9·98	9·34
Co. 366	9·72	8·49	11·12	15·43

Variety	December	January	February	March
Co. 368	8·70	7·78	9·91	15·79
Co. 370	10·22	11·09	15·87	14·21
Co. 371	9·42	12·14	11·91	13·83
Co. 374	13·52	11·84	16·53	14·89
Co. 377	7·00	7·75	5·72	9·30
Co. 378	10·91	13·37	15·41	16·83
Co. 381	12·59	15·83	15·06	13·13
Co. 382	12·05	11·41	13·88	13·96
Co. 384	8·10	11·41	14·79	14·55
Co. 386	7·03	6·94	12·40	15·04
Co. 391	6·45	8·03	10·70	12·51
Co. 394	3·77	5·57	5·54	8·12
Co. 413	6·80	9·99	11·22	14·09
Co. 417	9·10	9·50	7·92	..
Co. 419	7·53	8·96	9·90	9·37
Co. 421	10·32	9·88	14·88	15·17
Co. 423	7·62	6·96	10·12	9·65
Co. 424	5·17	8·32	11·49	12·20
Co. 425	8·24	10·04	9·50	14·50
Co. 426	6·99	6·87	9·26	13·30
Co. 427	7·85	10·00	11·15	8·35
Co. 428	9·95	7·98	8·26	10·22
Co. 429	8·10	2·16	13·06	11·68
Co. 430	6·31	10·70	2·89	15·80
Co. 431	6·96	6·10	12·81	10·71
Co. 432	9·30	11·27	12·10	15·56
Co. 433	4·93	6·35	8·13	13·59
Co. 434	8·45	8·30	10·50	13·68
Co. 500	14·00	10·36	16·73	17·20
Co. 501	8·70	9·56	10·03	12·58
Co. 502	6·01	5·09	9·01	10·50
Co. 503	9·52	11·07	12·99	11·81
Co. 504	7·57	7·25	5·89	9·92
Co. 505	11·80	8·46	12·71	14·97
Co. 506	7·73	8·63	13·27	13·90
Co. 507	6·71	6·98	6·24	12·00
Co. 508	7·85	10·88	10·25	11·10
Co. 509	8·97	4·53	14·12	8·52
Co. 510	4·38	3·43	9·35	12·79
Co. 511	6·24	6·97	8·88	12·59
Co. 512	7·61	9·32	12·11	15·50
Co. 513	6·60	5·00	10·27	14·77
Co. 514	9·80	9·69	12·52	14·25
Co. 516	5·52	6·06	8·33	10·90
Co. 441	5·12	5·19	2·68	..
Co. 442	5·63	7·00	9·90	..
Co. 443	8·35	9·21	9·50	..
Co. 444	6·00	10·27	11·21	..
Co. 445	6·76	8·25	10·76	..

4. Silage and Hay

Silage.—Making silage was common farm practice at Pusa. Maize was the chief crop which made excellent silage, but at Delhi difficulty has been experienced in growing it successfully to-date. *Jowar* which suits the soil of this place was, therefore, grown instead.

There are six standard pit silos (Pusa design)—two attached to the bullock byre, two near the dry stock lines and two attached to the milch byre. Five out of these were filled with green chopped *jowar*, the details of which are given below :—

No. of silo	Date of filling	Total green fodder filled in (Mds.)	Date of feeding	Quantity of silage obtained (Mds).	Percentage loss
Bullock byre—					
No. 1	2-8-37 to 6-8-37	2,918	7-11-37 to 9-12-37	2,780	4·7
No. 2	2-9-37 to 7-9-37	2,151	10-12-37 to 31-12-37	2,010	6·6
Dry stock—					
No. 1	8-9-37 to 11-9-37	2,078½	16-5-38 to 19-6-38	1,715	17·5*
No. 2	12-9-37 to 14-9-37	2,419	Not opened.		
Milk byre—					
No. 1	23-9-37 to 27-9-37	2,130	1-1-38 to 10-2-38	2,030	4·7

* Probably filled too young.

Unlike at Pusa, the *jowar* silage thus made, possessed a sweet and pleasant smell and was of olive green colour. All cattle relished it, especially the milch cows and young calves. Chemical analysis of *jowar* silage from bullock byre pit No. 1 is given below :—

	Per cent
Moisture	77·50
Oil (Ether extract)	0·32
Crude proteids	1·27
Soluble carbohydrates	10·00
Fibre	9·04
Soluble mineral matter	1·19
Sand	0·68
	100·00
Total nitrogen	0·203
Albuminoid nitrogen	0·089

Hay.—At the end of the berseem season, the surplus green berseem was converted into hay and 1,995 maunds excellent feeding material was obtained which proved very useful as a mixing fodder when bulk green fodders were insufficient.

Certain important precautions are essential for making good berseem hay, *viz.*, (*i*) the less the handling, the better the hay, as the leaves shatter easily, (*ii*) the correct time to cut berseem for hay is just when it is coming into flower, (*iii*) the crop should be left in the field after it is cut so that the upper surface dries off, and it should then be turned over gently and laid up in rows, (*iv*) the dry hay then should be carted directly to the sheds or stacks, preferably in the early morning on dry days.

5. Crops grown for the other Sections of the Institute

An area of five acres has been set aside in Shadipur A for growing sectional crops. The following is the list of crops grown for the Imperial Entomologist for the study of insect pests. In addition to the crops mentioned below, an area of 0·125 acre has also been planted under sugarcane varieties in April, 1938.

Kharif.—Lady's finger, melon, sponge-gourd, maize, *jowar*, pigeon pea, castor, bottle-gourd, cowpeas, soybean, *guar*, urid (*Phaseolus Mungo* var-*Roxburghii*), *moong* (*Phaseolus radiatus*) and cotton varieties (M 60-A_2, 289F, 4F and local).

Rabi.—Brassica varieties (*taramira*, *sarson* and *toria*), peas, gram, knol-kohl, turnips, beans, spinach, cabbage, cauliflower, linseed, holly-hock, potato, carrot, brinjal, radish and tobacco.

Half an acre sugarcane Co. 213 was grown for the Imperial Agricultural Chemist for a jaggery experiment with activated carbon, but the *gur*-plant could not be got ready before the crushing season. The crop was, therefore, sold.

An area of 0·50 acre was planted under sugarcane in February and March 1938 for the Plant Pathologist for the study of sugarcane mosaic. Small plots were also laid out behind the Mycological laboratory for the Imperial Mycologist.

IV. FIELD EXPERIMENTS

1. Berseem Experiments

Inspite of the fact that berseem, one of the best fodders in the world, was introduced into India some 34 years back, it has not spread and gained as much popularity among the farmers and cultivators in India as it should have done. There seem to be two reasons for this. Firstly, the difficulty of obtaining reliable pure seed at a cheap rate; secondly, the high irrigation rate of water required to grow it. At Pusa, berseem could not be induced to set seed, and irrigation cost was difficult to assess. Directly we arrived at Delhi, these two problems confronted us.

To investigate the above two problems, experiments were laid out on the farm during the *rabi* season 1937-38. The results are summarised below :—

(*i*) *Berseem seed production experiment, Main Block, plot No. 6.*—In this experiment, the crop was left for seed after five cuttings had been taken from December to April. From the results of the experiment given, it will be seen that the maximum quantity of seed was obtained after the third cut taken in mid-February. The seed obtained from all cuttings was of normal size and healthy.

The experiment was laid down in randomised blocks with six replications.

Treatments	Mean yield of seed per plot in oz. (·022 acre)	Percentage on general mean	'z' test	Critical difference
Berseem seed obtained after—				
A—1st cutting (December) .	22·17	109·92	Significant at the 5 per cent level	15·080 (P=·01)
B—2nd cutting (January) .	26·58	131·82		
C—3rd cutting (February) .	27·75	137·60		11·057 (P=·05)
D—4th cutting (March) .	12·42	61·57		
E—5th cutting (April) .	11·92	59·09		

Conclusions :—A=B=C ; D=E ; B=C>D=E.

The results of the duplicate experiment carried out at Karnal are given below :—

Treatments	Mean yield of seed per plot in oz. (·022 acre)	Percentage on general mean	'z' test	Critical difference
Berseem seed obtained after—				
A—1st cutting (November)	30·67	102·32	Significant at the 1 per cent level.	9·146 (P=·01)
B—2nd cutting (December) .	27·67	91·82		6·706
C—3rd cutting (January) .	38·00	126·11		(P=·05)
D—4th cutting (February) .	30·58	101·49		
E—5th cutting (March) .	23·58	78·26		

Conclusions :—C>A, B, D & E ; A and D>E.

From the above results it will be seen that the maximum quantity of seed was obtained after the third cut. This confirms the results obtained at New Delhi.

(*ii*) *Irrigation experiment on berseem, Main Block, plot No. 6.*—Green berseem was irrigated at different intervals to determine the optimum irrigation interval for successful growth of this crop. The experiment was conducted in randomised blocks with six replications. The land was of uniform texture and of medium loam. It is evident from the results given below that the yield of green fodder obtained from the crop with 12 days' irrigation interval does not differ significantly from that got from 8 days' and 10 days' irrigation intervals.

Treatments	Mean yield of green fodder per plot in lb. (·022 acre)	Percentage on general mean	'z' test	Critical difference
Irrigations at—				
A—8 days' interval . .	1,624·9	116·99	Significant at the 1 per cent level	305·883 (P=·01)
B—10 days' interval . .	1,604·4	115·51		
C—12 days' interval . .	1,463·5	105·37		224·278 (P=·05)
D—16 days' interval . .	1,030·1	74·16		
E—20 days' interval . .	1,221·9	87·97		

Conclusions :—A=B=C>D=E

2. Varietal yield trials

Two varietal yield trials with wheat and gram were carried out during the year under report and their results are briefly stated below. :—

These two experiments were conducted purely with the intention of finding out how far the newly reclaimed and levelled land is suitable at present for such trials. Although the plots selected were considered fairly uniform according to the condition of the previous crop, yet during the conduct of the actual experiments, considerable variations were observed from plot to plot.

(*i*) *Yield trial with wheat, Middle Block, plot No. 1.*—The trial was carried out in Latin Square with six replications.

Varieties	Mean yield of grain per plot in lb. (·0165 acre)	Percentage on general mean	'z' test	Critical difference
C. 591	41·42	107·66	Significant at the 1 per cent level	5·550 (P=·01)
8-A	38·75	100·72		
C. 518	45·00	116·97		4·070 (P=·05)
P. 12	36·58	95·09		
P. 114	31·96	83·07		
P. 165	37·13	96·50		

Conclusions :—8-A=P. 12=P. 165>P. 114; C. 518>8-A, P. 12, P. 114 and P. 165; C. 591> P. 12, P. 114 and P. 165

(*ii*) *Yield trial with gram, Main Block, plot No. 12.*—The experiment was laid down in randomised blocks with six replications.

Varieties	Mean yield of seed per plot in lb. (·0167 acre)	Percentage on general mean	'z' test	Critical difference
T. 17	21·65	90·14	Significant at the 1 per cent level	7·800 (P=·01)
T. 25	29·85	124·31		
T. 58	29·12	121·24		5·766 (P=·05)
P. F. 3	28·97	120·63		
P. F. 6	14·23	59·25		
P. F. 11	20·27	84·41		

Conclusions :—T. 17=P. F. 11>P. F. 6; T. 25=T. 58=P. F. 3>T. 17, P. F. 6 and P. F. 11.

This experiment was also duplicated at Karnal, and the results are tabulated below.

Varieties	Mean yield of seed per plot in lb. (·0167 acre)	Percentage on general mean	'z' test	Critical difference
T. 17	8·472	85·56	Significant at the 5 per cent level	5·617 (P=·01)
T. 25	10·027	101·27		
T. 28	5·845	59·03		4·186 (P=·05)
T. 58	14·687	148·33		
P. F. 3	12·970	130·99		
P. F. 6	8·390	84·74		
P. F. 11	9·375	94·69		
P. F. 17	9·445	95·39		

Conclusions :—T. 58>T. 17=T. 25=P. F. 6=P. F. 11=P. F. 17; T. 58=P. F. 3>T. 17=P. F. 6.

T. 28 and P. F. 17 did not do well at New Delhi and, therefore, these were excluded for the statistical analysis. T. 25, T. 58 and P. F. 3 have given better yields than other varieties both at New Delhi and Karnal. It will also be seen that the yield of gram was poor at Karnal.

3. *Experiments on alternative fodder crops.*—As a preliminary trial, the following *rabi* green fodder crops were grown as alternative fodders to berseem. Unfortunately, the piece of land on which these crops were grown turned out to be very poor in condition and light. Berseem gave two cuts and others were cut once only. The yields are given below.

Name of crops	Area in acre	Yield of green fodder (in Mds.) Total	Average per acre
Berseem	0·25	55·70	222·80
Kerao (*Pisum arvense*)	0·25	56·50	226·00
Barley and *kerao*	0·25	36·00	144·00
Khesari (*Lathyrus sativus*)	0·25	48·10	192·40
Methra (*Trigonella* sp.)	0·25	19·10	76·40
Senji (*Melilotus parviflora*)	0·25	25·70	102·80

4. Summary of results of sugarcane manurial experiments conducted at Pusa during the past seven years

A large number of manurial experiments were carried out on Co. canes at Pusa, and the data together with their results obtained in different years have been given in the respective reports of the Section. An endeavour is made here to collate all these results up-to-date.

Sulphate of ammonia and nitrate of soda.—Nitrate of soda gives slightly higher tonnage yield of sugarcane than sulphate of ammonia, but the differences are not statistically significant. Application of these fertilizers in two half doses is more conducive to tonnage yield than a single dose. Further, manuring just before the break of monsoon is more helpful to sugarcane than at other times of its growth.

Rape cake and superphosphate.—Different doses of nitrogen as rape cake and phosphoric acid as superphosphate were tried in various combinations on sugarcane, and it was found that a mixture of 40 lb. N and 50 lb. P_2O_5 per acre is better than other combinations from the consideration of tonnage yield and economic point of view.

Artificial fertilizers and organic manures.—Application of artificial fertilizers in the form of 40 lb. N as sulphate of ammonia, 50 lb. P_2O_5 as superphosphate and 40 lb. K_2O as sulphate of potash per acre does not produce satisfactory tonnage yield unless the land is previously green-manured with sann-hemp.

Farmyard manure at 14 tons per acre has been found to be the best general manure for sugarcane.

Green-manuring with sann-hemp in conjunction with superphosphate at 50 lb. P_2O_5 per acre and rape cake at 40 lb. N per acre have been found to give the next best tonnage yield.

The manurial effect of river silt, tank soil and cattle standings was also studied and these were found to have very little effect on cane yields.

V. MACHINERY AND IMPLEMENTS

The testing of agricultural implements and machinery was continued, and the following were among the implements under test.

1. *A.-G. B. General Cultivator and Bullock Hoe* was continuously used for inter-culture of *kharif* crops sown in rows. The defects which were found during the course of work were brought to the notice of the inventor with suggestions for improvement. A reply was received that a new model had been brought out incorporating a number of our suggestions. This new model has now been received and will be placed under test.

2. *The Ramchandra water lift* was given a thorough trial both at Delhi and Karnal Substation. It was worked at Delhi alone and also simultaneously with a *charsa* lift for comparative test. The final report was submitted to the Director. The working of the Ramchandra water lift is based on sound principles, but expensive repairs and high cost of upkeep were the chief features of the trials both at Delhi and Karnal.

3. *A mechanical seed drill* was received from the Research Engineer, Coimbatore, and was assembled for trial. Certain defects were noticed before putting the drill to actual work in the field, and a reference in this connection has been made to the inventor.

4. *The Hissar S. 3-A Plough* was worked in comparison with the standard Victory plough throughout the season. It was found hard on the bullocks.

Dynamometer draught tests with all these and other implements will be started this year.

It is felt that inventors of agricultural implements do not always realise, especially if they are not agriculturists, the essential necessity of a thorough and searching trial by an experienced agriculturist at all stages before the implement is brought out to the public. We have had to return numerous implements with obvious agricultural faults based on the above.

VI. CATTLE BREEDING

1. The Pedigree Sahiwal Herd

This herd consisting of 13 breeding bulls, 71 cows, 44 young males and 65 heifers, a total of 193 head at the end of the year has now settled down in its new quarters, and it is possible to make certain comparisons directly affecting the herd due to the transfer from Pusa. A considerable improvement is noticeable in the health and weight of the calves and young stock,

and it has been possible to initiate further experiments with the concentrate rationing with a view to greater utilisation of the roughage, which appears to possess a greater feeding value to that at Pusa. The great improvement in the design of the buildings, especially the milch byre and calf sheds, has also contributed its share to the general health of the stock. Against this has to be placed the fact that due to the present traffic to Naraina passing through the Estate, we have suffered a considerable increase in contagious diseases, and I am afraid, until this passage is effectually closed, these needless losses will continue, our experiments being handicapped and valuable results lost through no fault of our own.

The Sahiwal cattle exhibited at the All-India Show at New Delhi took 1st and 3rd in bulls, 1st and 3rd in heifers and reserve in cows—a very satisfactory testimony to their first appearance in direct competition against cattle from the home of the breed in the Punjab, when it is realised that all the animals shown from here were bred in Bihar.

2. Milk Yield

The milch yield of the herd averaged 22·2 lb. against 20·7 lb. last year, and the percentage of cows in milk was 59·8 against 44·9 in 1936-37. The average yield per day of second calvers was 20·3 lb. and of heifers 17·8 lb. as compared with 19·5 lb. and 16·6 lb. in 1936-37.

Statement of milk yield for the year 1937-38

Month	Total yield (excluding stripping)	Average yield		No. of cows in milk and dry			
		Per day	Per cow per day	Total number milch herd	In milk	Dry	Percentage of cows in milk
	lb.						
July, 1937	30,048	969	24·4	76	40	36	52·6
August, 1937	31,234	1,008	24·2	76	42	34	55·3
September, 1937	29,761	992	23·8	78	42	36	53·8
October, 1937	31,208	1,007	22·8	76	44	32	57·9
November, 1937	27,964	932	20·9	78	45	33	57·7
December, 1937	29,981	967	20·6	77	47	30	61·0
January, 1938	33,338	1,075	20·8	80	52	28	65·0
February, 1938	29,915	1,068	21·2	66	50	16	75·8
March, 1938	29,961	966	22·2	65	44	21	67·7
April, 1938	27,298	910	22·5	66	40	26	60·6
May, 1938	25,069	809	21·8	66	37	29	56·1
June, 1938	23,707	790	21·0	70	38	32	54·3
Average	29,124	958	22·2	73	43	29	59·8
Average (1936-37)	20,066	659	20·7	71	32	39	44·9

Among the best individual performances were two cows reaching to over 11,000 lb. and 10,000 lb. respectively, five over 9,000 lb. and four over 8,000 lb. in 300 days' lactation.

It will thus be seen that out of an average of 43 cows in milk, 25 per cent of the milch herd was over 8,000 lb.

Cow Chansuri No. 653 is doing over 10,000 lb. for the second year in succession.

The heifers showed a steady improvement on last year,

Some of the best cows and heifers that completed lactations during 1937-38

Name and No.		Date of birth	No. of calving	Best lactation lb.	(days)
Cows.					
Laruli	604	20-10-29	4	11,003	(304)
Chansuri	653	11-3-32	3	10,223	(304)
Ramati	566	19-3-27	6	9,320	(306)
Birengee	631	14-1-31	4	9,222	(304)
Bilamba	674	10-12-32	2	9,193	(304)
Chengi	534	11-11-25	6	9,084	(303)
Amba	495	28-2-24	10	9,002	(304)
Choki	681	11-3-33	2	8,676	(303)
Birbutia	659	16-5-32	3	8,661	(304)
Lalmil	287	31-8-29	5	8,388	(276)
Lachmohni	644	10-9-31	3	8,129	(304)
Heifers					
Cholesari	717	16-3-34	1	6,833	(304)
Lakhrengee	732	13-8-34	1	6,315	(306)
Rajsuri	734	9-11-34	1	6,109	(279)
Bisamba	740	27-12-34	1	5,950	(304)
Lakhali	731	16-7-34	1	4,562	(304)
Lakhjai	737	2-12-34	1	4,284	(304)

3. Calf Rearing

In 1936-37 we reared 56 calves out of 59 born, and in 1937-38 we reared 66 calves out of 67 dropped.

This bears out my contention that pail-fed calf mortality from minor complaints on a properly run cattle farm should be almost *nil*.

Percentage of mortality amongst the pail-fed calves for 1937-38

Year	Births	Deaths	Percentage of mortality
1936-37	59	3	5·1
1937-38	67	1	1·5

4. Early Maturity

These experiments are now reaching a stage where they include almost all the herd, and I propose to devote a special section to their discussion as their effect on the herd is now so marked.

5. Sales of Cattle

The demand for our stock was greater than ever and thirty-five head were sold for Rs. 5,920 and this coupled with the sale of milk products realised a total of Rs. 18,579. When the public realise that no heifers are sold from this herd, much disappointment will be avoided.

Statement of cattle sold during the year 1937-38

Particulars	No.	Total price Rs.	Average Rs.	Average for 1936-37 Rs.
Cows	19	3,575	188 3 0	106 8 0
Heifers	2	300	150 0 0	60 0 0
Bulls	3	1,050	350 0 0	210 0 0
Young bulls	11	995	90 7 0	72 14 0
Total	35	5,920	..	..

6. Investigations

Considerable attention has been paid this year to four lines of work where data have become available:

(*i*) Transmission of characters.

(*ii*) Full brothers' and full sisters' parallels.

(*iii*) Stimulation before and after pregnancy and its effects on milk yield in heifers.

(*iv*) Work on skeletal alterations and their effect on milk yield.

It is becoming all too evident that a life time is too short for some of these investigations, and my hope that they would be taken up by a younger man working with some other herd has not yet materialised.

(*i*) *Character transmission* is now beginning to give us some definite data, but the work is of necessity very slow, as some four years have to elapse between each step. It is now, however, possible to identify throw-backs in the female line to heavy milkers and to study the effect on the transmission of milk and the possible linkage of these characters with yield.

(*ii*) *Full brothers and full sisters.*—We have now certain definite data regarding the get of full brothers, and it remains to check off this against a further set which are now being calved down.

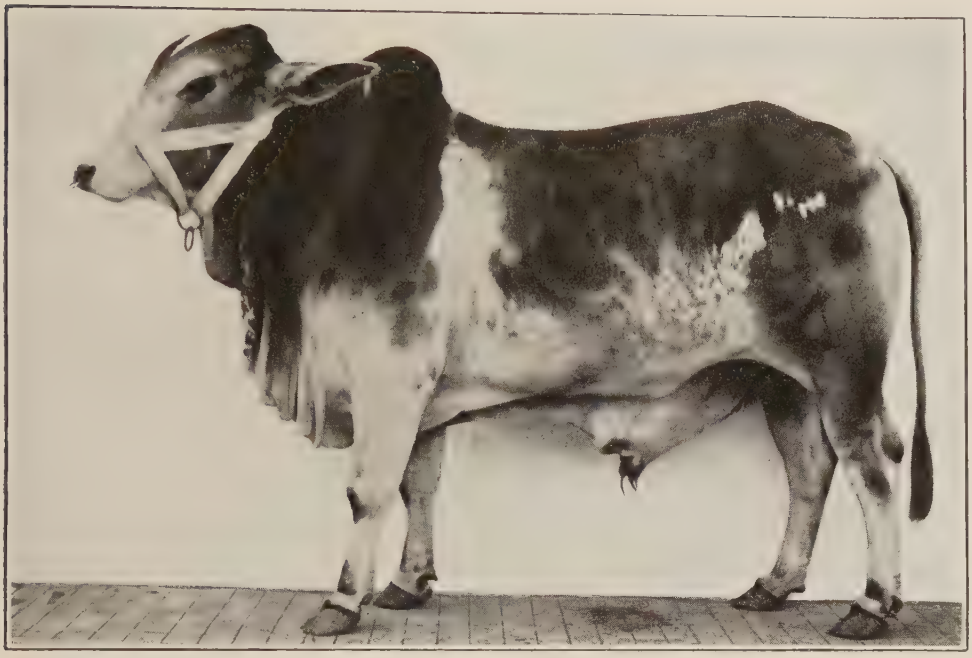
Full sisters.—Here correlation with some of the theories already published is being attempted, and the get from the use of the same sire over full sisters is being investigated further. It would appear that the necessary data from the use of full brothers over full sisters which will shortly be available should produce interesting results and possibly guide us further in the question of the variation in get between full brothers which is one of the great handicaps in our 'proved bull' investigation, while it is likely that some connection between the correlation of milk yield in full sisters should exist in heifer calves got from full sisters by full brothers.

(*iii*) *Stimulation.*—Work has been done on uncovered heifer No. 769 and covered heifer No. 776—both by the same sire.

Heifer No. 769 aged about two years started to give milk on 16th March, 1938, and has given 438 lb. upto 31st July, and is still milking; her udder is normal and secretion appears to be natural. The analysis of the milk shows 3 to 4·8 per cent fat content and a protein content of 3·8 to 5·42 per cent. In this case pregnancy appears to be unnecessary for inducing milk secretion and the stimulation of the act of milking keeps the flow steady. Heifer No. 776, covered on 25th December, 1937, started to milk after four months. She has given 1,169 lb. to-date and gives a steady 14 lb. per day. A feeding test is being done on this milk, and the heifer's condition is normal and in all respects she resembles a first calver carrying her second calf.

Statement of pre-milk of two heifers

Particulars	Date of birth	Date of service	Date of drawing milk	March 1938 lb.	April 1938 lb.	May 1938 lb.	June 1938 lb.	July 1938 lb.	Total lb.
Chansuri's Heifer No. 769 by Jeswant	18-3-36	18-7-38	16-3-38	29¾	113	123	98	75	438¾
Lalmil's Heifer No. 776 by Jeswant	10-6-36	25-12-37	29-4-38	,,	7	324	414	424	1,169



Early Maturity Sahiwal Bull Emden No. 649

Age at first service 1 year 9 months and 16 days

Early Maturity Heifer No. 775 covered at 1 year 6 months and 3 days

Out of an Early Maturity mother (Lakhati) by an Early Maturity bull (Emden). Mother also out of an Early Maturity cow (Lagati) by an Early Maturity bull (Lakhan)

Both cases lead one to the conclusion that stimulation in milking and handling has a much greater effect on the secretion and yield of milk than was hitherto supposed, and it would appear in cases where milch pedigree is well established, well grown early maturity heifers can be milked as *though they were pregnant for their second lactation.* It is difficult to see why such yield should be colostrum and not similar to the yield of a second calver. Condition shows no sign of strain, and growth and weight is normal for the age. This condition appears to be inherent in the get of one of our Early Maturity bulls.

(*iv*) *Work on skeletal alterations* in the Sahiwal breed has been continued, and a paper is in the press showing results to-date. The Sahiwal breed has certain characteristics in top line and udder which are distinctly detrimental to a high yielding milch breed, but which were highly valued by the old breeders.

Many of these so-called characteristics of the Sahiwal breed which were held to be linked to milch production have been bred out after some ten years' work, but the milk retained and the course set for a better hung high class vessel on a high yielding cow, which is essential if the breed is to take its proper place among the milch breeds of the world. Work on these lines can be profitably started on other breeds in this country who are also handicapped.

The annual statement of live-stock is given below :—

Annual statement of Live-stock as it stood on the 30th June, 1938

Description of cattle	Number of animals from last year.	Increase				Decrease					Total
		By birth	By transfer	By exchange	From Farm	By death	By transfer	By sale	Sent to Pinjrapole	By exchange	
Bulls for breeding	13	..	3	..	..	..	1	1	..	1	13
Bulls for sale	1	..	1	..	..	..	..	2	..	..	..
Cows—Milch herd	75	..	22	1	..	6	26	..	1	..	65
Cows—for breeding	1	..	..	..	..	..	..	..	..	..	1
Cows—for sale	..	..	26	..	..	2	..	19	..	..	5
Young male stock in dairy	30	35	3	..	..	2	20	..	..	2	44
Young male stock for sale	6	..	8	..	..	..	3	11	..	..	..
Young male stock—steerlings	..	..	9	..	..	..	..	..	..	..	9
Young female stock in dairy	56	32	..	2	..	1	24	..	..	..	65
Young female stock for sale	..	..	2	..	..	..	..	2	..	..	..
Bullocks	5	..	..	..	2	1	..	..	2	..	4
Total	187	67	74	3	2	12	74	35	3	3	206

VII. EARLY MATURITY WORK

This has proceeded steadily since 1932, when it was taken up as a major herd experiment, and has now reached a stage where it is possible to review the position.

The starting of the experiments raised questions of stamina and constitution and the possibility of weaknesses being developed in the subsequent generations. All these points have had to be carefully considered, noted on and recorded over a period of some five years. The special check weighments, experimental matings and careful investigation of all data provided have placed a heavy responsibility on the staff. Over and above all has come the milch record of the herd as a whole, where, as will be seen, a steady increase has been maintained. Our distribution of young bulls by Early Maturity mothers has gone on uninterruptedly despite the fact that in the middle of the experiments came the 1934 earthquake with its unparalleled dislocation of all work when luckily no immediate damage was done to the herd. Four times milking has been standard throughout the herd during these experiments, and it is clear that the Early Maturity animals bred have had every thorough test for stamina.

These Early Maturity experiments were taken up in addition to the work on milch improvement, line breeding, feeding and handling and calf rearing which we already had in hand, and as the herd is only of medium size, most of our Early Maturity stock has of necessity formed material for the above work.

Cows.—The percentage of Early Maturity milch animals in the herd (on 5th August, 1938) is now 73 against 27 ordinary. Most of the cows coming under the head of ordinary are first class old cows ranging from their 4th lactation upwards (upto 11th lactation), while there are seven controls of various ages representing the years 1931—1935.

The milk yield of the herd has steadily risen since the experiment was started, and now with 73 per cent Early Maturity cows in the herd, it is at its highest yet. It will thus be seen that the milk yield has not been affected in any way as is clear from the Table given below.

Milk yield per cow per day

Year	Percentage of Early Maturity cows in the herd (30th June)	Yield in lb.
1931-32	2·5	13·6
1932-33	21·3	17·9
1933-34	26·2	18·7
1934-35	40·0	19·1
1935-36	53·3	21·2
1936-37	61·8	20·7
1937-38	70·0	22·2

The Early Maturity cows in the herd have maintained health and weight in a perfectly normal fashion.

Early Maturity Sahiwal Heifer Erengee No. 704

Out of an Early Maturity mother by an Early Maturity bull

(Won 1st prize in the heifer class at the All-India Cattle Show, 1938)

PLATE III

Weight of Early Maturity cows

Name and No.	Weight at 1st covering	Weight at 22nd week in lactation				Remarks
		1st lactation	2nd lactation	3rd lactation	4th lactation	
						Weight at—
Birengee	631	553	668	777	849	944	
Bripla	649	625	876	896	999	1,022*	*20th week
Chansuri	653	647	785	820	868		
Brukta	654	498	739	808	828	878*	*14th week
Naruli	665	494	704	769	847		
Birbutia	659	569	710	762	855		
Cholmi	677	575	751	861	1,016		
Noshni	686	549	649	743	790		
Chirengee	692	553	798	845	891		
Chakhni	698	572	812	950	981		
Choki	681	648	769	840	895*		*19th week
Chamatina	697	719	888	972	1,007*		*19th week
Cholbani	695	714	894	980			
Durdha	688	676	766	972			
Cholbina	699	634	781	909			
Chabri	704	617	756	962			
Machrama	706	550	634	757	799*		*4th week
Naraee	705	697	816	952			
Rajurki	710	608	770	964			
Lakhati	703	534	679	810			
Chaplari	702	700	816	950			
Rajbiri	711	555	712	895			
Mahasam	716	591	676	755			
Lakhali	731	682	874	987			
Lakhrengee	732	701	866	933*			*13th week
Lakhjai	737	698	863	909*			*7th week
Bisrukta	736	683	916				
Bisamba	740	710	924	980*			*5th week
Rajina	742	586	754				
Rajsuri	734	594	717				
Madrama	735	689	878				
Laprama	744	736	851				
Lengi	746	644	766				
Rajsoorti	750	600	744*				*8th week
Nalcham	751	654	796				
Lakhram	753	650	759				
Nalchand	760	764	943*				*20th week
Manoshi	754	672	663*				*20th week
Narbiri	755	665	696*				*18th week
Erengee	764	764	927*				*17th week
Naloorti	756	619	690*				*17th week
Majoki	758	611	643*				*11th week
Lakhamdi	765	727	877*				*9th week
Emdhani	763	712	851*				*5th week
Average		637·3	782·9	879·9	894·2		

Weight of controls

Lachmohini	644	..	667	794	856	916*	*3rd week
Chamati	662	718	930	950	1,005		
Charoochi	667	689	764	783	879*		*10th week
Bilamba	674	810	840	950			
Cholesari	717	659	822	902			
Mapari	738	676	798				
Nalakhi	748	865	938*				*8th week
Average		736·2	822·7	875·8	913·3		

The controls being considerably older at that date naturally had a heavier covering weight of 736 lb. against 637 lb. Early Maturity, but in the subsequent lactations the weights tend to even off as 823 lb. to 782 lb. Early Maturity in the first lactation, 876 lb. to 880 lb. Early Maturity in the second lactation and 913 lb. to 894 lb. Early Maturity in the third lactation, and no one unfamiliar with the herd can tell an Early Maturity from an ordinary cow by the third lactation other than by referring to the records.

The weight at birth of the calves dropped by Early Maturity cows whether by Early Maturity or ordinary bulls as contrasted with those dropped by the controls are given here.

Calf weights at birth

	Early Maturity (lb.)	Control (lb.)
1st calving	45·3	47·3
2nd calving	50·2	50·2
3rd calving	50·8	53·3

It will be seen that the first calves are somewhat lighter in both the groups, and subsequent calvings show the normal rise to herd average. The weights of the calves at 40 weeks are normal and no trouble has been experienced, other than an occasional case of weakness, in rearing any Early Maturity calves.

The calf mortality figures from 1932 are given, and when it is remembered that the whole herd was transferred to an entirely new environment in 1936 which represented a big change for the 1936 calves and the cows which were due down, they must be considered eminently satisfactory. The earthquake conditions of 1933-34 and 1934-35 were quite abnormal as far as calf-rearing was concerned.

Calf mortality

Year	Percentage of calves from Early Maturity in herd	Mortality per cent	Remarks
1931-32	1·5	3·0	
1932-33	21·4	1·4	
1933-34	33·8	13·2	Mica poisoning after earthquake followed by foot and mouth
1934-35	79·0	24·2	
1935-36	77·0	1·6	
1936-37	83·1	5·1	Whole herd moved to Delhi
1937-38	97·0	1·5	

Bulls—Early Maturity bulls (1) Lakhan, (2) Nala, (3) Bisoon, (4) Jeswant, (5) Emden, (6) Onkar have now all got stock in milk or due to calve. They are in regular service with the exception of Nos. 3 and 6 which have been sold. They are active, well grown and fully developed. Bull Lakhan won third prize in the class for Sahiwal bulls at New Delhi All-India Show in February, 1938, while Emden's first heifer by an Early Maturity cow won the heifer class with another Early Maturity heifer by Nala standing third.

Erengee No. 764, an Early Maturity heifer covered at 1 year, 4 months and 26 days out of an Early Maturity mother Birengee No. 631 by an Early Maturity bull, Emden won the heifer class at the All-India Show, New Delhi, in February, 1938, standing well away from the rest of the class—in size, quality, scope and make, despite the great difference in age. She was over a year younger than some of those shown in the same class.

It is now possible to say that these experiments have proved what we set out to solve:

1. That Early Maturity can be produced with its great increase of time in profit.

2. That it causes no deterioration in constitution or milk yield.

3. That there is nothing inherent in the Sahiwal breed which demands the late maturity associated with this breed for so long.

It must also be stated definitely that there is nothing in Early Maturity which improves the milk yield of a heifer. She merely starts yielding at an earlier age and is therefore in a position to give more milk in a normal life. Breeding for milch improvement is an entirely separate investigation.

A full report is now in course of preparation.

VIII. PUBLICATIONS

The undermentioned articles were published during the year under report:—

1. Sayer, Wynne — The Rearing of Pail-fed Calves. *Agri. & Live-stock in India*, **7**, 1937, 493-502.

2. ———— — Berseem (*Trifolium alexandrinum*). *Herbage Pub. Series* (Aberystwyth) Bull. No. 23, 1937, 36-38.

3. ——— & Sen, S. — Manurial Experiments with Sulphate of Ammonia and Nitrate of Soda on Sugarcane. *Agric. & Live-stock in India*, **8**, 1938, 165-166.

IX. PROGRAMME OF WORK FOR 1938-39

1. Mixed farming including the study of rotations for building up the soil to a high level of fertility.

2. The study of irrigated and unirrigated crops.

3. Investigations on fodder crops for soiling, hay, silage and green fodder and their seed production.

4. Conduct of field experiments for testing manures and crops including sugarcane.

5. Dynamometer investigations on resistance of soil to bullock-drawn implements.

6. Testing of agricultural implements and machinery.

7. Conduct of experiments for the other sections of the Institute.

8. Continuation of cattle-breeding operations on the pedigree Sahiwal herd with special reference to the transmission of milch characters.

9. Special feeding of the young stock with a view to early maturity in the Sahiwal herd.

10. Training of post-graduate students.

2. AGRICULTURAL SUBSTATION, KARNAL

I. CHARGE

This sub-station was in charge of Mr. S. M. Jamaluddin during the year under report.

II. FARM AND CULTIVATION

1. General Cultivation

The year under report is the first in which it has been possible to deal with the entire arable area—the *batai* having been finally terminated in June 1937. The whole area is now able to come under proper operations at the correct time. 1,175 acres were taken under direct cultivation during the year, and this will enable us to deal with the whole technique of large-scale experiments in mixed farming.

The survey and verification of the total area of the farm has been started to enable the correct boundaries to be delineated.

It is impossible to lay the area out for controlled experiments until an outlet for surplus water is provided, while the general layout and remodelling of the irrigation is forced to wait on the drainage. The crop yields and general condition of the farm and stock are materially affected by this delay which renders the task of the staff more difficult in many ways.

Levelling and layout was continued as far as possible under the circumstances, and a large area in No. 6 was remodelled.

The Steam Tackle was brought from Delhi at the conclusion of the heavy levelling work there and put on to plot No. 7, where extensive deep work was required. The steam tackle implements, though now in the last stage of their 25 years' life, did all that could be expected of them.

2. Rainfall and Crop Yields

The total rainfall during the year under report amounted to 23·55 inches as against 29·34 inches of the previous year and 40·61 inches in 1935-36.

The crop yields under direct cultivation were as follow. Yield of the previous year is given in brackets.

Statement of crop yields under direct cultivation

Crops	Area in acres	Yield in maunds		
		Total	Average per acre	
Maize—corn	4·18	40·13	9·60	(5·80)
Maize—green fodder	54·73	7,101·50	129·76	..
Jowar—green fodder	120·52	21,006·63	174·30	..
Soy-bean	3·42	26·83	7·85	(6·34)
Cowpeas	3·22	16·73	5·20	(6·11)
Sann-hemp seed	8·67	75·30	8·69	(12·62)
Cotton	0·30	2·96	9·87	..
Paddy	2·97	44·64	15·03	..
Oats	520·56	9,498·33	18·25	(16·20)
Gram	200·15	1,839·85	9·19	(19·72)
Wheat—				
P. 4	26·50	648·18	24·46	(16·49)
P. 12	10·00	232·00	23·20	
P. 80-5	34·24	803·00	23·45	
P. 111	10·00	245·25	24·53	
P. 114	6·00	135·45	22·58	
P. 120	6·00	112·18	18·70	
P. 165	25·66	516·20	20·12	
Barley	35·71	341·33	9·56	(12·85)
Peas	4·74	7·59	1·60	(19·27)
Flax-seed	5·00	47·13	9·43	..
Berseem-seed	14·00	28·58	2·04	(3·30)
Berseem—green fodder	23·97	14,870·60	620·38	(814·81)

It will be seen that a general rise in crop yields over the area was obtained. The gram crop was affected by wilt and failed over a large area, while the portion grown after late *jowar* was affected by the shortage of rain. Both wheat and oats yielded excellent crops, but the barley T. 21 was affected by smut.

3. Fodder crops

The *kharif* cropping was devoted mostly to fodder growing, and it is of the greatest importance to discover and test the best and most productive fodders at Karnal, as the conditions differ equally from Delhi and Pusa and require separate investigation to enable us to run the farm and the herd in the best and most economical fashion.

4. Berseem

A large scale investigation on this valuable fodder crop was started combining (1) fodder supply, (2) water requirements, (3) land improvement, (4) hay and silage, (5) seed and (6) threshing. It has been impossible in the past at Pusa to deal with items 2, 5 and 6, as climatic conditions were not suitable. At Karnal the position is different and all sides of the investigation were able to be dealt with. The first stage is that of investigating the correct balance to be kept between green fodder and seed, *i.e.*, the time to cease cutting in order to obtain maximum seed production following the largest possible maundage of green fodder. How important the seed problem is can be realised by taking the price of seed from N.-W. F. P. costing Rs. 35 per maund and by no means free of weed and contrasting it with the fact that 95 per cent clean seed at Rs. 20 per maund can be produced at Karnal under controlled cultivation. We are also now able to thresh berseem seed by machinery which enables us to handle a much larger crop with perfect

safety. The details of the experiments are given below. They were laid down with a view to studying the problems as to—

(1) after which cutting the crop would yield most first class seed,

(2) minimum and maximum number of irrigations and the amount of water required by the crop for seed production,

(3) time when the last watering should be done,

(4) determining the manurial requirements of the crop for seed production, and

(5) its harvesting and threshing programme.

The results so far obtained are very encouraging.

5. Field Experiments and Miscellaneous work on crops

(1) Gram yield trial and berseem cutting experiments for seed were carried out during the year, and the results have been included in the Delhi report for purposes of comparison.

(2) A manurial experiment with sulphate of ammonia, nitrate of soda and their mixture was conducted on three varieties of paddy, and it was found that (*i*) sulphate of ammonia alone and (*ii*) the mixture gave a better outturn of grain.

(3) A detailed study of cowpeas was undertaken as a part of co-operative Empire crop study at the instance of the Director, Royal Botanic Gardens, Kew. The work was started at Pusa in the year 1935-36 when 511 samples of seed received from various parts of the world were sown in *kharif* season, *i.e.*, last week of June 1935-36. The work was continued at Karnal. Observations were made on the lines of the questionnaire issued by Kew, which included the study of general morphological and agricultural characters, such as habit, maturity, vigour, yield, disease resistance and the incidence of insect attack.

(4) About thirty acres of land was worked for the Imperial Economic Botanist's Section to enable them to carry on their cultural yield trials, and other experiments on different crops on this substation.

(5) Cotton was grown on 0·30 acre for the Imperial Entomologist's Section for their observation of boll worm and other insects.

(6) Sugarcane was grown for the Plant Pathologist on an area of two acres for his tonnage and mosaic experiments.

(7) The Imperial Mycologist carried on his experiments on smuts, gram wilt and other plant diseases.

(8) Flax was grown on five acres for the Assistant Fibre Expert, Bengal.

6. Tractors and Machinery

The large area of land under direct cultivation has placed a great strain on our cultivating machinery. Two McCormick Diesel tractors were purchased in 1936, and these have dealt with a large acreage apiece in very thorough style. They have been more or less assisted by the remains of our Pusa tractor fleet, all of which were in the last years of their 'run out' and maintenance trials when transferred to Karnal. The two Lanz tractors and the Vickers are now finished, and it will be necessary to replace them to avoid

straining the remaining tractors unnecessarily. The steam tackle has assisted to handle a large area, but this outfit cannot work satisfactorily until the farm drainage has been completed and the roads laid out to simplify working, and as spare parts are no longer made, its days are now numbered. It has given us 25 years thoroughly reliable service. The mowers and threshers require replacement and considerable attention will have to be paid to the silage machinery as replacement and repair costs are mounting. The complete lay-out of two farms in three years has taken a heavy toll of land implements.

7. Seed Distribution

This was one of the main functions done on the farm during the year, and the following seeds of pure varieties were issued to different provinces, States, Talukas all over India during the year.

Name and variety of seed	Total quantity issued Mds.
Oats	12·20
Wheat—	
P. 4	442·15
P. 12	161·83
P. 80-5	267·20
P. 111	108·73
P. 120	8·20
P. 165	88·53
P. 114	22·64
Total	1,111·48

III. CATTLE BREEDING

1. Breeding Herd

In January 1938, the Hariana herd of 229 head was transferred to Izatnagar for genetical work with the exception of certain animals sold to the Punjab Government at Hissar and some sixteen rejects which were auctioned off. The entire attention of the cattle staff was then able to be concentrated on the Tharparkar herd of 240 head.

The general health of the stock and calves was satisfactory considering the conditions prevailing. Preventive inoculation against rinderpest was carried out with goat virus by the staff of the Imperial Veterinary Research Institute on 64 animals.

A line of new calf boxes was built during the year, and this has materially contributed to better health in the calves.

The old barracks in which the herd is housed were condemned, and steps have now been taken by this department to put two of these barracks into a habitable condition for a couple of years.

Six typical Tharparkars were exhibited at the All-India Cattle Show at New Delhi in February 1938, winning three first and three second prizes

List of animals exhibited at the Cattle Show.

Name and No. of animal	Class	Order of merit won in the Show
Qais . 10	Bull	1st prize
Lear . 5	Bull	2nd. prize
Fakiran . 64	Cow	1st prize
Biro . 49	Cow	2nd prize
Machkani . 105	Heifer	1st prize
Razadi . 144	Heifer	2nd prize

The herd will be further culled as soon as the points for registration of Tharparkar pedigree stock are published.

2. Milk Yield.

The improvement in the milk yield of this herd is shown in the statement below :—

Statement showing milking average per cow per day in the Tharparkar herd

Months	1936-37	1937-38.
July	16·8	22·1
August	16·6	21·7
September	16·4	19·5
October	15·6	18·9
November	15·1	19·0
December	15·7	18·4
January	16·4	19·4
February	16·2	19·4
March	18·8	20·4
April	19·5	20·9
May	20·8	21·5
June	20·4	21·2
Average	17·4	20·2

The average milk yield of cows which completed their full lactation during the year is given together with those obtained in two previous years.

Milk yield of cows which completed their full lactation during the last three years.

Year	No. of cows	Average milk yield (lb.)	Average No. of days in milk
1935-36	57	3,838	283·0
1936-37	69	4,422	276·1
1937-38	56	5,716	284·1

Records of six best cows and six best heifers which completed their lactations during the year under report are given below :—

Records of best cows and heifers which completed their lactations during the year 1937-38

Name and No.	No. of calvings	Milk yield (lb.)	Days in milk
Cows—			
Kutni 21	7	8,785	305
Katili 35	6	9,064	305
Kumari 36	5	7,443	305
Toti 39	5	7,599	305
Tumbi 48	5	7,506	305
Biro 49	5	7,453	305
Heifers—			
Rafikan 88	1	5,587	305
Rahmi 108*	1	5,609	305
Ratti 106	1	5,179	305
Bhago 107	1	5,621	305
Machkani 105	1	6,254	305
Miro 120*	1	5,333	266

* Early Maturity heifers.

The milk yields of individual cows give a clear indication of the possibilities of this breed in the milch line, and it would appear that with proper selection, handling and feeding, they will be among the best milch breeds in India within a decade. I personally consider, this breed shows the greatest possibilities, if properly handled, in the next few years.

3. Pre-milking and Handling

Four times milking, pre-handling and milking and calf rearing coupled with Early Maturity work were continued on the herd. The results speak for themselves.

Statement showing the record of Early Maturity heifers

Name and No. of animal	Date of birth	Age at service Y.M.D.	Weight of calf at birth lb.	Performance lb.	Remarks.
Rahmi 108	1-7-34	1 10 3	48	5,609	
Miro 120	30-12-34	1 9 22	53	5,333	
Mafzi 115	16-11-34	1 11 4	48	4,321 in 275 days and giving 11 lb. per day.	
Ramdi 130	9-6-35	1 10 28	50	2,553 in 121 days and giving 19 lb. per day.	
Phijji 133	11-8-35	1 10 29	49	2,066 in 80 days and giving 25 lb. per day.	
Laila 143	16-1-36	1 7 18	47	642 in 29 days and giving 22 lb. per day.	

4. Calf Rearing

There were 86 births during the year and all the calves were weaned and reared. The percentage of mortality is given below. The number of calves lost due to ordinary ailments is steadily dropping. A large number of calves were lost due to insanitary condition of the buildings and bad drainage.

Mortality amongst pail-fed calves (Tharparkar) during 1937-38.

Year	No. of calves reared	Deaths	Mortality per cent.
1936-37	129	13	10·1
1927-38	152	15*	9·9**

* 9 died of infectious diseases.
** Mortality percentage due to ordinary ailments—3·9.

The calf weighment figures are given below :—

Average weight of calves at birth and at one year's age, for the last two years

Year	No. of calves born	Average weight at births lb.	No. of calves completing one year's age during the year	Average weight at 1 year's age lb.	Average weekly increase from birth to 1 year lb.
1936-37	77	48·5	56	470·6	8·6
1937-38	86	49·7	66	510·2	9·8

5. Sale of Cattle.

Thirty-five young bulls were sold during the year at an average price of Rs. 52 as against Rs. 23 of the previous year. A lively demand for Tharparkar bulls is in evidence now and will increase as the herd gets better known for pedigree and performance. Sixteen Tharparkar cows were also sold during the year.

The Tharparkar herd is now the practical expression of the results obtained with the Pusa Sahiwal herd at Delhi. The idea is to put into practice all the methods we have found successful with the parent herd and thus show the public what can be done by using a herd which uptil a few years ago was not considered in any way an example. It is therefore of great interest and value to see the results obtained in all cattle husbandry branches by staff who have been trained properly, and the rapid improvement in quality, milk yield, and health of the herd is best shown by the improved prices the stock is fetching.

The work which has been accomplished on this farm both among the stock and on the land is now becoming clearly visible, and if the major improvements which are so essential can be expedited, further rapid improvement will be facilitated.

The annual statement of livestock is given in the table below :—

Statement of live-stock for the year 1937-38

Particulars	Balance on 1st July 1937	Increase		Decrease				Balance on 30th June 1938
		By transfer from other stock	By birth	By death	By sale	Sent to Pinjrapole	By transfer to other stock	
Bulls . . .	6	4	...	...	...	...	1	9
Cows . . .	92	20	...	1	16	1	...	94
Young stock female .	77	...	41	13	...	...	20	85
Young stock male .	59	...	45	7	35	...	2	60
Total .	234	24	86	21	51	1	23	248

3. STATISTICAL BRANCH

(P. V. Krishna Iyer)

I. REVIEW OF SOME OF THE MANURIAL AND MISCELLANEOUS EXPERIMENTS CARRIED OUT AT PUSA

1. New manurial experiment

This experiment is being carried out on a four-year rotation basis and was started in 1932. The rotation followed is maize, oats; maize, peas; maize, wheat; and maize, gram. Manure is applied year after year. Farmyard manure and rape cake are applied in *kharif* and artificials half in *kharif* and half in *rabi*. The other details regarding this experiment are mentioned in the Imperial Agriculturist's reports for previous years.

Results.—For maize, 40 lb. N per acre as rape cake has proved superior to 8,000 lb. farmyard manure per acre. For the winter crops, there seems to be no difference between rape cake and farmyard manure. In some years complete artificials (*i.e.*, 40 lb. N as $(NH_4)_2SO_4$, 80 lb. P_2O_5 as superphosphate and 50 lb. K_2O as K_2SO_4) came up to the level of farmyard manure. Potash did not increase the yield of any crop. In fact there was a tendency to depress the yield.

It was also found that maize preceded by gram and peas gave a fairly high outturn, the former being better than the latter. The yield of the maize crop after oats and wheat was low in all the plots except those manured with 40 lb. N as rape cake.

2. Results of green manure experiments on oats

(*a*) *Comparative value of different green manures.*—(*i*) Among the different species of *Crotalaria*, *C. Muijussi* was the best. (*ii*) sann-hemp, *dhaincha*, *guar*, cowpeas, velvet bean and *meth* were better legumes for green-manuring than soybean. The first four stand almost on the same level. *Urid* as green manure was inferior to sann-hemp. (*iii*) After burying sann-hemp or indeed any green manure, it was found advisable to stir the land.

(*b*) *Green manure buried at different periods of its growth.*—(*i*) There was no difference between green manuring with sann-hemp six weeks old and with that ten weeks old. (*ii*) To be effective, sann-hemp 8 weeks old and ploughed down without cutting had to be buried 9″ deep, while that six weeks old had to be buried only 6″ deep. Sann-hemp 8 weeks old and cut into pieces, when buried 6″ deep gave satisfactory yield with oats.

(*c*) *Effect of artificials and fermentation on green manure.*—(*i*) There was no significant difference between sann-hemp treated with superphosphate and bone-meal both applied in two doses in June and September. (*ii*) Green-manure in conjunction with superphosphate gave a higher yield than when applied alone. Sann-hemp six weeks old *plus* $\frac{3}{4}$ maund superphosphate per acre yielded the best outturn of oat crop. As regards the time of application of superphosphate, it was immaterial whether it was applied with sann-hemp or at the time of sowing the *rabi* crop. (*iii*) Six times sann-hemp (*i.e.*, sann-hemp grown on 6 acres and applied on one acre) applied after fermenting gave the highest outturn. The residual effect continued for two to three years without any appreciable deterioration as judged from the control plots to

start with. Fermented sann-hemp with superphosphate also gave a high outturn and the fertility of the plot was maintained at a fairly high level even at the end of the fourth year, no manure being applied during the intervening period.

(*d*) *Different portions of plant as green manure.*—Different parts of plants (*viz.* whole plant, leaves, stem and roots) were tried on oats in small plots, and it was found that leaves alone gave better yield than either the whole plant or any of the other parts. But subsequent experiment on field scale showed that there was no difference between the yield of oats produced from the whole plants and leaves.

3. Manurial experiments with sugarcane

(*a*) Fourteen tons farmyard manure per acre was the optimum amount required for sugarcane under the Pusa conditions.

(*b*) Forty lb. N as rape cake *plus* 50 lb. P_2O_5 as superphosphate per acre gave a fairly good yield, but less than that of 14 tons farmyard manure. The addition of potash did not increase the yield.

(*c*) Green manure *plus* standard manure (*i.e.*, 40 lb. N *plus* 50 lb. P_2O_5) yielded less than 14 tons farmyard manure.

4. Miscellaneous experiments

(*a*) *Ploughing experiment.*—A ploughing experiment carried out with six types of plough, *viz.*, Desi, Pusa, Hindustan, Shanti, Bihar, and Victory ploughs, for four years on an unreplicated basis to raise maize, wheat, barley, peas and pigeon-pea crops showed that Victory plough was the best. Desi, Hindustan and Pusa were more or less on the same level. Shanti and Bihar ploughs were not so good as the others.

(*b*) *Seed-rate experiment for oats.*—Four seed-rates, 25 seers, 30 seers, 35 seers and one maund (per acre) were tried, and it was found that there was no difference between the final yields obtained from the various seed-rates followed.

II. INVESTIGATIONS

1. Adequacy of fifth degree orthogonal polynomials for representing Pusa rainfall data

Efforts were made to see how far the weekly rainfall data of Pusa for twenty-seven weeks commencing from April 1st for the years 1909 to 1935 can be represented by fifth degree orthogonal polynomials. The distribution values a′, b′, c′, d′, e′ and f′ were calculated for each year. The total sum of squares of the deviations of rainfall for different weeks from the mean value, the reduction in error due to the fitting in of the constants b′, c′, d′, e′ and f′, the residual variance and the coefficient of variation on the basis of residual variance after fitting the polynomial were also calculated for every year.

It was found that the reduction in error due to the fitting of the polynomial was not so high as to enable us to consider the polynomials as satisfactory fits to the rainfall data. Further the values of b′, c′, d′, e′ and f′ calculated were not significant in the majority of cases even at the 5 per cent. level. Since b′, c′, d′, e′ and f′ which represent the distribution of rainfall are not significant, it is doubtful whether any useful curve representing the relation between rainfall and yield of a crop can be had for Pusa conditions by the use of the distribution constants, *i.e.*, the determination of the distribution constants which involves heavy computational labour may not enable us to arrive at any useful relation between the yield of a crop and rainfall, especially for India, where the rainfall is very discontinuous.

2. Relation between yield of maize and rainfall

The partial regression coefficients between the yield of maize and rainfall in the months of June, July, August, September and in the remaining eight months of the year prior to sowing were worked out on the basis of figures available for (1) the whole Pusa Farm and (2) Permanent Manurial Experiments at Pusa. None of the regression coefficients worked out for maize was significant, thereby showing that under Pusa conditions any additional inch of rainfall over the average for the period under consideration did not produce any significant increase or decrease in the yield of the crop.

3. Balanced *versus* randomised arrangement in field experiments

In a paper published in the February (1938) issue of *Biometrika*, the late Mr. W.S. Gosset showed how a balanced arrangement is preferable to a randomised layout. To see whether there is any difference between the errors obtained in the case of randomised and balanced arrangement, the variances of a number of lay-outs involving 5, 6, 7 and 8 treatments with eight replications were worked out on the basis of uniformity trials' data available on the farm after superposing the treatments (1) at random and (2) on a balanced basis. The results obtained are tabulated below :—

Place and Crop	Size of plot	No. of treatments	No. of replications	Residual Variance		Variance of Dummy treatments	
				Balanced	Randomised	Balanced	Randomised
Karnal—							
Wheat P. 114	30′×25′	5	8	1,195·0	1,211·5	259·5	143·7
Wheat P. 114	30′×30′	6	8	3,143·8	3,207·9	3,079·1	2,630·7
Wheat P. 114	30′×20′	7	8	955·0	870·8	152·4	742·1
Wheat P. 114	30′×25′	8	8	2,346·0	2,116·7	1,334·5	2,939·5
Pusa—							
Sugarcane Co. 205	12′×151¼′	5	8	47,940·8	45,135·3	37,920·9	57,560·0
Sugarcane Co. 205	9′×121′	6	8	26,802·4	26,244·3	16,276·5	20,183·7
Sugarcane Co. 205	9′×151¼′	7	8	44,459·1	39,075·8	25,872·3	63,555·0
Sugarcane Co. 205	6′×151¼′	8	8	19,674·8	17,758·9	5,319·5	18,731·1
Sugarcane Co. 210	21′×120′	5	8	22,060·9	27,385·5	57,197·5	19,925·9
Sugarcane Co. 210	18′×120′	6	8	20,474·8	28,505·7	77,292·8	21,077·0
Sugarcane Co. 210	15′×120′	7	8	12,305·6	18,833·3	59,525·2	13,831·6
Sugarcane Co. 210	18′×120′	8	8	88,282·3	96,766·6	164,640·1	105,250·5
Meghaul (Monghyr District)—							
Sugarcane Co. 213	21′×120′	5	8	38,188·6	35,684·3	5,254·6	22,784·7
Sugarcane Co. 213	18′×120′	6	8	26,809·7	25,352·6	3,769·5	13,968·8
Sugarcane Co. 213	15′×120′	7	8	23,098·3	21,583·3	12.246·8	22,851·8
Sugarcane Co. 213	18′×120′	8	8	24,685·8	28,162·4	30,396·3	6,059·8

It will be seen from the above table that the variance in the case of balanced and randomised arrangements are practically the same. Further, examining the error due to dummy treatments after superposing the actual treatments, we find that the significance of the treatments will be less in four and

more in three out of the sixteen cases examined. Therefore from a layman's point of view the chance of a systematic arrangement giving more efficient result is slightly more than that of the randomised arrangement. But theoretical considerations, on the basis of which statistical tests are built up, demand that the layout should be randomised, and therefore it is always better to randomise the treatments in the field.

4. Efficiency of incomplete randomised blocks

Yates has shown how the efficiency of field experiments involving a large number of treatments can be considerably increased by adopting the method of symmetrical incomplete randomised block layouts. The actual efficiency of a few symmetrical incomplete randomised layouts, on the basis of four uniformity trials carried out at Pusa, Monghyr and Karnal, which have already been dealt with in the previous section, was worked out for layouts involving 11, 13, 16 and 21 treatments and the details and results are given below. The errors of ordinary randomised layouts and symmetrical incomplete layouts were calculated by superposing the treatments at random. The efficiency was estimated by using the formula $\frac{100\ t\ (k-1)}{k\ (t-1)} \times \frac{\sigma^2}{\sigma_k^2}$ where σ^2 is the variance of ordinary randomised layout and σ_k^2 is that of incomplete randomised block layout.

Crop, place and year	Size of plot	No. of treatments t	No. of replications r	No. of treatments per block k	No. of times a pair of treatments is repeated λ	Efficiency
Sugarcane Co. 210, Pusa 1934.	60′×21′	11	5	5	2	98·21
Sugarcane Co. 210, Pusa 1934.	60′×21′	13	4	4	1	175·64
Sugarcane Co. 210, Pusa 1934.	60′×15′	16	6	6	2	142·00
Sugarcane Co. 210, Pusa 1934.	60′×15′	21	5	5	1	157·40
Sugarcane Co. 213 Monghyr 1933.	60′×21′	11	5	5	2	99·37
Sugarcane Co. 213 Monghyr 1933.	120′×18′	13	4	4	1	99·18
Sugarcane Co. 213 Monghyr 1933.	60′×18′	16	6	6	2	124·49
Sugarcane Co. 213 Monghyr 1933.	60′×15′	21	5	5	1	102·35
Wheat P. 114 Karnal 1936-37.	5′×5′	11	5	5	2	124·03
Wheat P. 114 Karnal 1936-37.	20′×15′	11	5	5	2	84·10
Wheat P. 114 Karnal 1936-37.	25′×15′	13	4	4	1	54·24
Wheat P. 114 Karnal 1936-37.	30′×20′	13	4	4	1	204·86
Wheat P. 114 Karnal 1936-37.	20′×10′	16	6	6	2	126·80
Sugarcane Co. 205, Pusa 1932.	121′×9′	11	5	5	2	116·60
Sugarcane Co. 205, Pusa 1932.	151¼′×9′	13	4	4	1	146·10
Sugarcane Co. 205, Pusa 1932.	90¾′×6′	16	6	6	2	108·40
Sugarcane Co. 205, Pusa 1932.	121′×6′	21	5	5	1	166·94

An examination of the table will show that the efficiency of incomplete randomised blocks is definitely more when the number of treatments is more than thirteen.

5. Theoretical investigations

It has been shown how the Dirichlet's integral can be utilised to derive the distribution of (1) the means and the standard deviation of samples from normal populations (2) the means of samples of Types I and III curves. The distributions obtained are identical with those obtained by Irwin and others. The importance of the method lies in the fact that it can be used to obtain the distribution of sums of any powers of the variates of samples from Type III population.

The exact distribution of Pearson and Neyman's L_1 test for three samples (*i.e.* k=3) of equal sizes has been obtained in the form of a definite integral with finite limits involving L_1 only.

REPORT OF THE IMPERIAL ECONOMIC BOTANIST

(B. P. Pal)

I. INTRODUCTION

The levelling and laying out of the greater portion of the Botanical Area was completed and crops of wheat, barley, oats, gram, peas, lentils, linseed and potatoes were grown. The growth of crops was very satisfactory, especially in the case of the cereals. Thus, for example, of the six varieties of Pusa oats which were grown, all with but one exception, yielded at the rate of over thirty maunds of grain per acre (Plate IV). Part of the experimental work was carried out at the substations at Pusa and Karnal. At the close of the year, however, the work at the latter place was transferred to New Delhi. The assistance received from the Imperial Agriculturist and his staff during the period the work was in progress at Karnal is gratefully acknowledged.

Increasing attention is being paid to the genetical side of the Section's activities. In breeding work special stress is laid on disease resistance.

The living crop collections were maintained.

II. TRAINING

(*i*) *Post-graduate Training.*—Messrs. Nek Alam, C. A. Joseph, S. Sen and G. Ranganathaswami completed their course during the year.

Messrs. K. K. Khosla, T. Narayana Rao and S. Solomon continued to receive training. In addition to the usual post-graduate work, they were engaged upon original research on problems of correlation in linseed, seed-setting in gram, and chromosome doubling in a sterile tobacco hybrid, respectively.

The new admissions during the year were: Messrs. R. M. Arora (United Provinces), A. B. Joshi (Central Provinces), S. L. Juneja (Punjab) and G. S. Murty (Madras).

The post-graduate students were at the Botanical Substation, Pusa, for about three months, and at headquarters for the rest of the year.

(*ii*) *Short Course in Flue-curing of Tobacco.*—This was conducted at the Botanical Substation, Pusa, and was attended by the following students:—

Mr. S. V. Ramchandra Iyyer (Madras).

Mr. Lodhi A. K. Khan (Sind).

Mr. Murli Dhar (United Provinces).

Mr. Mustaq Ahmad Khan (United Provinces).

Mr. K. S. Saxena (United Provinces).

Mr. Risal Singh (United Provinces).

Mr. D. B. Patel (Baroda).

(*iii*) *Other Courses.*—Mr. P. M. Ganguli of the Assam Department of Agriculture, who joined the Botanical Substation, Pusa, on March 20, 1937, for training in plant breeding, left on September 20 in the same year.

A field of Hybrid Coats in the Botanical Area

PLATE IV

III. SUB-STATIONS

The following Sub-stations, financed by the Imperial Council of Agricultural Research, are under the direct control of this Section :—

(*i*) Botanical Sub-station, Pusa.

(*ii*) Potato Breeding Sub-station, Simla.

(*iii*) Wheat Breeding Sub-station, Simla.

(*iv*) Tobacco Research Sub-station, Guntur.

The work done at the Sub-stations during the year under review is given in detail in the respective reports on these Sub-stations submitted separately to the Imperial Council of Agricultural Research. The more important features of the experimental work done at the Sub-stations are briefly indicated under the appropriate heads in the present report.

IV. RESEARCH

Genetics and Breeding of Crop Plants.

Wheat (Triticum vulgare Host)

(*i*) *Yield and Bushel Weight.*—The yield of wheat was very satisfactory (see Crop Outturns) keeping in mind the fact that considerable damage had been done in the seedling stage by white ants. Pusa 125 was the highest yielder, thus repeating its success of last year at Pusa and Karnal. Bushel weights were as follows :—

Bushel weights of wheat varieties in 1937-38

Variety	Weight per bushel in lb.
Pusa 4	65·88
Pusa 12	62·75
Pusa 80-5	66·24
Pusa 111	65·30
Pusa 114	65·24
Pusa 120	63·00
Pusa 125	62·92
Pusa 165	65·00

(*ii*) *Milling and Baking Tests.*—Milling and baking tests of Pusa 120 and Pusa 165 wheats were carried out in England, by arrangement with the Research Association of British Flour Millers, the cost being borne by the Imperial Council of Agricultural Research. The results showed that these two wheats are very near in respect of quality to Pusa 111 (one of the controls) which has the reputation of being one of the highest quality wheats produced thus far in India.

(*iii*) *Yield Trials.*—The series of yield trials mentioned in the last annual report were repeated.

(*a*) Yield trial of early-maturing hybrids from the cross Pusa 52 × Federation. The results are summarised in Table I.

TABLE I

Summary of results of early varietal yield trial conducted at Karnal in 1937-38

Varieties	Mean yields of grain in lb. Yields per acre	As a percentage of the general mean
Pusa 80-5	2,548·73	101·16
Pusa 121	2,478·28	98·76
Pusa 122	1,774·64	70·72
Pusa 125	2,783·43	110·92
Pusa 126	2,699·25	107·56
Pusa 165	2,769·70	110·37
General mean	2,509·38	100·00
Standard error of difference	79·33	
Whether z test significant	Significant	
Critical difference for significance (P = 0·01)	221·07	

P. 125 = P. 165 = P. 126 = P. 80-5 = P. 121 > P. 122.

P. 125 > P. 80-5 = P. 121 = P. 122.

P. 165 > P. 121 = P. 122.

(*b*) Yield trial of medium and late-maturing hybrids from the cross Pusa 52 × Federation. The results are given in Table II.

TABLE II

Summary of results of late varietal yield trial conducted at Karnal in 1937-38

Varieties	Mean yields of grain in lb. Yields per acre	As a percentage of the general mean
Pusa 114	2,530·20	92·33
Pusa 120	2,486·31	90·73
Pusa 121	2,682·99	97·91
Pusa 123	2,789·67	101·81
Pusa 124	3,030·24	110·58
Punjab 8A	2,490·75	90·89
Punjab C. 518	3,171·36	115·73
General mean	2,740·22	100·00
Standard error of difference	136·29	
Whether z test significant	Significant	
Critical difference for significance (P = 0·01)	375·03	

C. 518 = P. 124.

> the others

P. 124 > P. 114 = 8A = P. 120.

The late-maturing hybrid, Pusa 124 has thus again yielded satisfactorily, but Pusa 121 which gave very good results last year has not maintained its position.

(*c*) The yield trials with Pusa wheats carried out in the United Provinces and the Punjab with the kind co-operation of the Directors of Agriculture of these Provinces were repeated. The results of the previous year (1936-37) have been kindly summarised by the Statistician and are given below : —

TABLE III

Results of Co-operative varietal trials on wheat carried out in the United Provinces (1936-1937)

Lay-out—Randomised Blocks

No. of replications—6

Ultimate plot size—1/80 acre.

Local averages for 1/80 acre in lb.

Places → / Variety ↓	Balraich	Bichpuri	Fyzabad	Gorakpur	Hardoi	Kalai	Kalyanpur	Meerut	Nawabganj	Pratabgarh	Raya	Shahjahanpur	General averages	Remarks
P. 4	22·67	21·50	37·63	25·72	20·80	19·01	18·00	35·65	19·31	16·74	30·00	20·08	23·93	This variety has done well at Fyzabad, Meerut and Raya but was not satisfactory at Kalyanpur and Pratabgarh.
P. 12	22·83	21·83	21·50	24·18	21·34	17·65	21·33	28·55	19·13	17·85	26·67	20·42	21·94	At Meerut and Raya it has done well and badly at Kalai and Pratabgarh.
P. 52	22·17	21·50	28·60	20·75	23·87	20·04	23·00	22·71	16·26	20·45	28·00	22·83	22·51	It has done well at Fyzabad and Raya and was not satisfactory at Nawabganj.
P. 80-5	22·50	24·33	19·10	23·49	20·83	18·89	22·17	34·29	22·43	15·12	36·00	21·42	23·38	It has done best at Meerut and Raya and worst at Pratabgarh.
P. 111	19·33	23·83	23·90	31·21	19·43	18·50	17·83	32·92	19·35	15·21	33·83	20·33	22·97	Done best at Gorakpur, Meerut and Raya and badly at Pratabgarh and Kalyanpur.
P. 120	21·33	17·00	16·63	21·60	21·58	19·68	20·50	26·87	20·19	14·69	26·33	21·33	20·64	Done best at Meerut and Raya and badly at Pratabgarh, Fyzabad and Bichpuri.
P. 165	20·83	23·33	26·98	30·70	20·61	20·47	21·00	33·07	21·81	15·72	33·17	19·83	23·96	Done best at Gorakpur, Meerut, Raya and badly at Pratabgarh.
C. 13	22·00	22·83	19·10	23·66	22·35	16·87	23·33	33·60	21·09	19·39	30·00	24·50	23·23	Done best at Meerut and Raya and not very satisfactory at Kalai.
Pb. 518	21·00	13·17	20·00	28·46	23·55	17·04	22·50	36·86	18·54	19·65	30·17	19·58	22·54	Done best at Gorakpur, Meerut and Raya, done badly at Bichpuri and Kalai.
S. E. of local averages.	1·128	1·048	1·331	1·517	1·017	1·133	0·916	1·616	1·127	0·902	1·598	1·001	0·354	

S. E. of mean difference for any two varieties or localities = 1·73.

Remarks on the behaviour of various varieties at different places.
Varietal differences are not significant.
Pb. 518 and P. 120 are worse than the other varieties and accounts for the major portions of variance due to treatments. The differences between the other varieties are *not* significant.
P. 4 > P. 52 = P. 165 > other varieties. P. 120 is the worst.
P. 111 = P. 165 = Pb. 518 > other varieties, the differences of which are not significant.
Varietal differences are not significant.
Varietal differences arenot significant.
P. 4 = P. 111 < P. 52 = C. 13 the other varieties which are all on the same level.
Pb. 518 = P. 165 = C. 13 = P. 4 = P. 80-5 > P. 120 = P. 12 > P. 52.
P. 4 = P. 12 = P. 80-5 = P. 111 = P. 120 = P. 165 = C. 13 = Pb. 518 > P. 52.
P. 52 = Pb. 518 = C. 13. P. 12. The other varieties are inferior to the above but on the same level.
P. 80-5 = P. 165 = P. 111 > P. 12 = P. 52 = P. 120. Pb. 518 = C. 13 = P. 4 < P. 80-5.
Pb. 518 = P. 165 < C. 13.
P. 4 = P. 80-5 = P. 165 = C. 13 > P. 12. Pb. 518 < P. 165 = P. 4. Pb. 518 = C. 13 = P. 80-5 = P. 111 = P. 52. *P. 120 is the worst.*

TABLE IV

Results of the Co-operative wheat trial carried out in the Punjab (1936-37)

Lay-out—Randomised Blocks

No. of replications—6

1/80 acre—Local averages in seers

Variety	Gurdaspur (Barani)	Gurdaspur (chahi)	Hansi	Jullundur	Lyallpur	Montgomery	General averages
8-A	4·92	8·17	17·67	14·75	..	8·17	9·57
P. 12	..	9·58	15·33	13·54	11·83	9·17	10·39
P. 80-5	5·17	15·00	16·17	12·75	15·44	12·17	11·47
P. 114	4·29	10·75	14·00	11·92	12·45	8·50	9·32
P. 120	4·90	10·83	14·00	12·13	10·16	6·67	8·86
P. 125	2·88	5·50	20·75	15·54	14·33	14·56	12·26
P. 165	4·71	18·58	16·50	11·58	15·83	9·33	11·41
C. 518	..	10·75	19·17	16·00	14·66	11·33	12·45
S. E. of local averages	0·706	0·565	0·768	0·471	0·763	0·454	0·259

S. E. of mean difference for any two varieties or localities = 0·898.

S. E. Md. 366.

P. 125 is the worst while the rest show no difference.

P. 165 > P. 80-5 > P. 12 = 8A = P. 120 = P. 114 = C. 518 > P. 125.

P. 125 = C. 518 and these are the best of the lot while all the rest are equal except 8A which is superior to P. 114 and P. 120.

C. 518 = P. 125 = 8A > P. 165 = P. 114 = P. 120 = P. 80-5.

P. 165 = P. 80-5 = C. 518 = P. 125, and P. 120 = P. 114 = P. 12 < P. 165 = P. 80-5.

P. 125 ranks first and behaves better than P. 80-5 = C. 518 = P. 165 = P. 12 = P. 114 = 8A > P. 120.

C. 518 = P. 125 > P. 165 = P. 80-5 > P. 12 > 8A = P. 114. P. 120 is the worst. Other differences not significant.

The results of the season which is just over are not yet available.

(*iv*) *Breeding Work.*—The study of non-shedding variants from Pusa 114 and Pusa 120 wheats was continued. Several promising cultures obtained from off-type plants in Pusa 111 were also under observation.

Breeding for rust resistance was carried out at the Wheat Breeding Sub-station at Simla. During the year F_3 populations of a number of crosses after being tested for resistance in the seedling stage by Rai Bahadur Dr. K. C. Mehta were planted out in the field and studied. At maturity, plants were selected for carrying on to F_4, on the basis of rust-resistance and other desirable characters. The hybrid populations were thoroughly studied with a view to finding out if there existed any correlation between resistance to rusts and any other obvious and easily determinable morphological character. The results so far have, however, been negative.

The study of several new crosses, and the collections of Indian and foreign varieties was continued at Simla. Some early and medium-early crosses were grown at Pusa and Karnal.

The Section is now undertaking the development of wheat strains immune from or highly resistant to loose smut and flag smut, in co-operation with the Mycological Section of the Institute.

(*v*) *Genetical Studies.*—The study of the influence of certain external factors upon the manifestation of heterosis in wheat having been completed, the results were analysed and written up in the form of a paper which was read at the meeting of the Indian Science Congress held in January 1938, and subsequently sent for publication. A concise account of this investigation is given below.

A review of the vast literature on the subject disclosed that very few investigators had studied heterosis from this angle. Among the few who had done so were Bredemann and Heuser * who worked on rye and Bolsunov † who worked with tobacco. Their results indicated that further studies on these lines might throw light on the yet imperfectly understood causes of hybrid vigour. Accordingly, hybrid vigour was studied in a cross between two varieties of wheat, Pusa 52 and Pusa 165, under different dates and times of sowing, different depths of sowing and different conditions of spacing.

In total germination the F_1 was not superior to the parental varieties except when sowings were made at depths of 4-6 inches. Both time and depth of sowing, however, considerably affected the rate of germination. The percentage increases of the F_1 over the better parent for morning, noon and evening sowings were 6·7, 9·5 and 14·5, and for 1-inch, 3-inch and 5-inch sowings, 5·1, 8·9 and 12·5 respectively. The differential response to sowing at different depths was even more prominent in the case of sowings made late in the season.

It was found that hybrid vigour as shown by the rate of formation of the first four foliage leaves and the first tiller was affected by all the factors under study. The differences between the F_1 and the better parent (in favour of the former) varied from as much as 20·5 per cent to *nil*. Heterosis was also observed in respect of plant height, but sowing at different depths and spacings did not produce any differential response in respect of this character.

* Bredmann, G. and Heuser, W. *Z. Züchtung*, A, 1931 : 16 : 1-56.

† Bolsunov, I. I. *U. S. S. R. Institute of Tobacco Investigations* Bull. No. 132, 1936, 118-128.

Special attention was paid to the study of tillering in the hybrids and their parents, as tillering is a good criterion of vigour in wheat. The difference in tillering between the F_1 and the better parent was more striking in the earlier than in the later sowings, the percentage increase in favour of the F_1 varying from 46·2 to *nil*. There were indications that sowing at different depths and spacing exercised an influence on this character, but the effect of season appeared to be comparatively unimportant. The influence of the several factors studied on number of leaves per plant was similar to that on tillering.

The F_1s and the parents were compared in respect of length of ear, number of fertile and sterile spikelets, number of grains per ear and weight of grain. The differences between the F_1s and the better parent were in all cases not significant, but the former invariably exceeded the average of both the parents. In regard to total yield of grain per plant the F_1 was significantly superior to the better parent in the earlier sowings, indicating that heterosis occurs in respect of yield.

The results of the investigation indicate that the expression of hybrid vigour is greatly influenced by various external factors. It, therefore, appears to be desirable to study this phenomenon under as wide a range of conditions as possible to extend our knowledge of it. This is particularly so with crops such as tomato, tobacco, etc., where there is the possibility of commercial exploitation of hybrid vigour. In such cases it may be worthwhile to determine what are the optimum conditions for the expression of hybrid vigour in order to derive the maximum benefit from the use of F_1 seed.

(*vi*) *Registration of Wheat Varieties.*—At the suggestion of the Wheat Committee of the Imperial Council of Agricultural Research, work on the registration of wheat varieties has been kept in abeyance pending the publication of the recommendations of the committees appointed to report on cotton and rice nomenclature.

Barley (*Hordeum vulgare* L.)

The work on this crop is being carried on mainly at the Botanical Substation at Pusa.

Oats (*Avena sterilis* L. var. *culta* and *Avena* spp.)

The resistance of Pusa varieties of oats to covered smut is being studied with the collaboration of the Imperial Mycologist, and particulars of the experiment will be found in the Report of the Imperial Mycologist.

The production and testing of oats for fodder purposes was continued at Pusa.

Rice (*Oryza sativa* L.)

The results of the yield trials conducted for three successive years at Karnal have demonstrated the superiority in yield of Types 125, 130 and 164 over the varieties used as controls. The first two types being fine grained their seeds are now increased for distribution. Another strain, Type 137, though inferior to the strains just mentioned in yield is gaining in popularity on account of its fine and slightly scented grain.

The study of chlorophyll deficient plants, and the field trials of selected strains were continued at Pusa. The collection of types was maintained.

Maize (*Zea Mays* L.)

Inbreeding was continued. Out of about 1,200 selfed lines, some 600 promising ones were selected and inbred further.

A physiological experiment was undertaken to ascertain the relationship in translocation between the main stalk and the tillers of the maize plant. A study of the leaf anatomy of the " dead leaf-margin " type as compared to the normal, was in progress also.

The seedling counts as to the segregation of V_{21} indicated a close linkage between Y and V_{21}. The F_2 generations of the crosses of glossy 94 × glossy 9A, and glossy 94 × glossy 326 were studied. Each segregated into 9 normal : 7 glossy ratios, indicating that glossy 94 is not allelomorphic to either of the other two glossies.

Linseed (*Linum usitatissimum* L.)

(*i*) *Genetical.*—The F_3 generation of the cross Type 15 × Tamme's " crimped " was grown and the buds of all white-flowered plants were tested with dilute hydrochloric acid. Those plants which did not give a pink reaction were selected ; it is expected that some of them will be found to be lacking all the major petal colour factors.

The F_3 of the cross between Type 12 and the yellow-tipped mutant (mentioned in previous reports) was studied and confirmed the conclusion arrived at last year that there is a single factor difference between the normal and the mutant type.

Plant height, seed size and seed weight were studied in the F_1 of a cross between Type 124 and a flax variety. The height of the F_1 plants was approximately equal to the average of the parents. The seed-size of Type 124, the bolder-seeded parent was dominant ; in seed-weight, however, the seeds of the F_1 were slightly heavier than those of the heavier-seeded parent (Type 124).

(*ii*) *Breeding.*—The breeding of rust-resistant strains was continued. F_4 progenies of the crosses made for this purpose were studied at Pusa and Karnal, the observations on rust attacks being facilitated by the heavy incidence of the disease at both the places. While none of the original Pusa types and fixed hybrids was free from rust at either Pusa or Karnal, only very few of the F_4 cultures were infected by rust. Further selections were made for rust-resistance combined with other economically important characters.

F_4 progenies of crosses between linseed and flax varieties made with the object of determining whether the production of satisfactory dual purpose strains is possible were also studied.

(*iii*) *Correlation Studies.*—The correlation between plant height, tiller number, seed size, yield, etc., was studied in a number of types and fixed hybrids.

Safflower (*Carthamus tinctorius* L.)

Wild safflower (*C. oxyacantha* Bieb.) was grown from seeds collected at Delhi. This species is dwarf, bushy, very thorny and very late-maturing as compared to the cultivated species. There were no well-marked differences between the plants save in respect of certain seed characters. Attempts to cross the two species were successful.

The F_3 populations from the crosses Type 1 × Type 6, Type 1 × Type 30 and Type 6 × Type 30 were studied to confirm the previous year's results on the mode of inheritance of flower colour.

Selections for breeding work were made in the F_3 and F_5 progenies of a number of crosses.

Sesamum (*Sesamum orientale* L.)

Breeding work with the object of producing high-yielding, white-seeded types was continued. Some of the hybrids now available appear to possess the desired combinations of characters but further trials are necessary to confirm this.

Oleiferous Brassicae (*Brassica* spp.)

Pollen germination and the biology of the flower were studied in *toria*. Crosses were again made to study the inheritance of self-sterility in Brassicas, and the material so obtained has been classified into self-compatible, self-incompatible and cross-compatible groups. Pseudo-fertility was observed in some of the types.

Pigeon-pea [*Cajanus Cajan* (L.) Millsp.]

The breeding of varieties combining wilt resistance with other economically desirable characters such as seed size, was continued at the Botanical Sub-station, Pusa.

Data on the mode of inheritance of a number of morphological characters, collected at Pusa before the transfer of the Institute to Delhi, were collated.

Gram (*Cicer arietinum* L.)

The study of inheritance of seed colour was continued at Karnal. Large populations again could not be grown because of the high mortality occasioned by wilt disease.

The F_3 generation of the cross between the simple-leaved mutant and Type 17 was under study also. Some of the F_1 plants from the cross between the narrow-leaved mutant and Type 25 were back-crossed to the recessive parent. The F_2 and back-cross progenies will be studied next year.

At Delhi the genetic analysis of this crop plant has been begun afresh. Previous work on the subject was consulted and a programme of work drawn up. A number of crosses were also made and the F_1 generation of about five crosses will be under study next year.

Hibiscus (*Hibiscus sabdariffa* L. and *H. cannabinus* L.)

Four fixed hybrids from the cross between *albus* and New Hibiscus were grown alongside the latter for comparative tests. Arrangements are being made to have the fibres tested by the Assistant Fibre Expert to the Government of Bengal.

Cotton (*Gossypium* spp.)

A number of cotton varieties were grown and some crosses were made.

Tobacco (*Nicotiana Tabacum* L. and *N. rustica* L.)

Attempts were made to induce doubling of the chromosome number in the sterile *Tabacum-plumbaginifolia* hybrids by the use of colchicine. A few of the treated shoots appeared to respond and showed roughened appearance and slow growth. Later on, however, these shoots appeared to resume the normal condition. Cytological examination has not yet been made.

Preliminary experiments were also conducted on the effect of Hortomone A on root and callus formation in tobacco cuttings.

The available material of *N. rustica* was studied with a view to the production of strains combining heavy yielding capacity with high nicotine content; such strains would be of value for the commercial production of nicotine for use in insecticides, etc.

Work on cigarette tobaccos was continued at the Tobacco Research Sub-station at Guntur. Preliminary experiments were carried out on the effect of various fertilizers and combinations of fertilizers on the quality of cigarette tobacco leaf. A study of the effect of rotation crops on the growth and quality of the subsequent cigarette tobacco crop was also in progress. A few experiments were carried out to investigate the possibilities of replacing the coal used in flue-curing by cheaper fuels.

Leaf-curl disease investigations at Pusa were continued. While the incidence of the disease was much less than in the previous year the general trend of the results was similar. The series of monthly sowings was done in duplicate: in the first set the seedlings were kept exposed in the usual way while in the second the seedlings were protected from insects until transplanting time. The object of this experiment was to see whether by protecting seedlings until transplanting time the subsequent incidence of leaf-curl could be diminished. The results indicate however that there were no significant differences between the two sets of plants in respect of disease incidence. The experiments carried out by the Entomological and Mycological Sections on this problem will be found in the Reports of these Sections.

Samples of cured leaf received from various centres in nine Provinces and States in connection with the Co-operative Tobacco Scheme* were valued; arrangements were also made to obtain independent valuations from commercial experts.

Potato (*Solanum tuberosum* L.)

The work on this crop is being carried on partly at Delhi and partly at the Potato Breeding Sub-station, Simla. Some cultures were also grown at the Botanical Sub-station, Pusa.

After eliminating duplicates about 50 cultures of potatoes from the Indian collection were selected for detailed study. Other material under study included 276 samples of Chilean *tuberosums*, 22 species of tuber-bearing solanums, and a large number of interspecific hybrids.

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* Financed by the Imperial Council of Agricultural Research.

The Imperial Agricultural Chemist kindly analysed the starch contents of six species of potatoes. The results were as follows :—

Species	Percent starch on dry matter (sun-dried)	Percent starch on original sample
S. tuberosum (Cult. 256)	61·16	12·76
S. andigenum (Cult. 63)	59·15	14·90
S. demissum (Cult. 039)	51·94	18·14
S. ajuscoense	50·41	23·35
S. aracc-papa	49·76	15·32
S. leptostigma	49·92	14·07

It is evident that there is ample variation in starch content and breeding for high starch content is therefore possible.

Attention was primarily devoted to the study of disease resistance. Late Blight appeared late in the season and the relative susceptibility of the varieties and hybrids to this disease was studied. A large number of resistant plants were found in progenies of crosses between *tuberosum* and *andigenum* and, more especially, between *tuberosum* and *demissum*. The resistance of these cultures will be again tested under severe conditions of artificial infection with the co-operation of the Mycological Section.

Preliminary observations on cold resistance were taken. The study of flowering, pollen fertility and berry production was continued.

Chilli (*Capsicum annuum* L. and *C. frutescens* L.)

The F_2 generation of the cross between Type 1 and Type 2 was studied for the inheritance of colour of unripe fruit which is green in the former and creamy in the latter.

The F_2 of the natural species cross could not be repeated owing to heavy casualties as a result of diseases in the seedling stage.

Other Crops

Work on sunn-hemp (*Crotalaria juncea* L.), lentils (*Lens esculenta* Moench), black gram (*Phascolus Mungo* L. var. *Roxburghii*), green gram (*Ph. aureus* Roxb.), etc., was continued at the Botanical Sub-station, Pusa.

V. CROP OUTTURNS AND SEED DISTRIBUTION

As usual, reports on the crops obtained from the seeds supplied by the Section and its Sub-stations in the previous year were called for from the growers; these reports were tabulated and analysed. On the whole, the reports were very encouraging. An outstanding example is Pusa 52 wheat seed of which is supplied to cultivators by the Bihar Department of Agriculture and which has become the standard wheat in many parts of that province. It is stated to be now famous in the area south of the Ganges as "Collegia" wheat.

The crop outturns for the Botanical Area at New Delhi are given in the statement below :—

STATEMENT SHOWING THE YIELD OF CROPS IN THE BOTANICAL AREA AT NEW DELHI IN 1937-38

Crop	Variety	Plot No.	Area in acres	Outturn of grain in lbs.	
				Actual	Per acre
Wheat	P. 4	4	1·00	1,837·04	1,837·04
„	P. 12	3	1·00	2,310·18	2,310·18
„	P. 80-5	30	0·79	1,495·55	1,893·10
„	P. 111	29	1·00	1,672·46	1,672·46
„	P. 114	28	1·00	2,199·09	2,199·09
„	P. 120	27	1·00	2,038·63	2,038·63
„	P. 125	26	1·00	2,546·75	2,546·75
„	P. 165	25	1·00	2,063·32	2,063·32
Barley	T. 13	5	0·95	2,997·27	3,155·02
„	T. 21	6	1·00	2,548·81	2,548·81
Oats	B. S. 1.	7	0·83	2,306·06	2,778·39
„	B. S. 2.	8	0·83	2,114·75	2,547·89
„	VII-578	9	0·59	1,195·20	2,025·76
„	Hy. G	9	0·12	312·69	2,605·83
„	Hy. G	11	0·83	2,159·95	2,602·35
„	Hy. J	9	0·12	318·86	2,657·17
„	Hy. J	12	0·83	2,215·49	2,669·27
„	Hy. C	10	0·83	2,246·42	2,706·53
Gram	T. 25	14	1·00	711·77	711·77
„	T. 25	15	1·00	734·40	734·40
„	T. 25	16	1·00	750·86	750·86
„	T. 25	17	1·00	715·89	715·89
„	T. 25	18	1·00	709·72	709·72
„	T. 25	19	1·00	685·03	685·03
„	T. 53	20	1·00	806·40	806·40
„	T. 58	21	1·00	958·63	958·63
„	T. 58	22	1·00	812·57	812·57
Peas	T. 29	2	0·97	2,643·44	2,725·20
Lentil	T. 11	1	0·12	113·14	942·83
„	T. 47	1	0·10	45·26	452·60
„	III-86	1	0·12	109·03	908·58
Linseed	T. 12	23	1·00	588·35	588·35

The low yields of gram are mainly due to the high incidence of wilt disease.

Seeds were supplied both by the Section and the Botanical Sub-station, Pusa, to a large number of agricultural officers and private individuals in

India, and also to 28 persons outside India. The quantities of seeds distributed are shown below :—

STATEMENT SHOWING THE QUANTITIES OF BOTANICALLY PURE SEEDS DISTRIBUTED FROM 1ST JULY, 1937, TO 30TH JUNE, 1938

Variety of crops	Quantity Lb.	oz.
Wheat P. 4	1,200	5
„ P. 12	824	0
„ P. 80-5	455	5
„ P. 101	123	2
„ P. 111	475	10
„ P. 114	198	15
„ P. 120	458	15
„ P. 125	617	5
„ P. 165	1,567	8
Barley T. 7	1	0
„ T. 13	2,813	3
„ T. 21	1,703	1
Oats B. S. 1	2,786	9
„ B. S. 2	241	6
„ Hybrid C	1,658	4
„ „ G	248	1
„ „ J	1,583	10
„ „ A	1	0
„ „ K	1	0
Paddy T. 137	576	0
Gram T. 26	13	3
Peas 14-1	20	6
Flax J. W. S.	240	7
„ Liral Morarch	144	0
Linseed T. 12	8	2
Pigeon-pea T. 24	1	0
„ E. 50	1	0
„ T. 80	1	0

VI. ADVISORY

As usual a large number of enquiries were received from correspondents regarding varieties, methods of cultivation, curing, etc., and the information required was supplied.

VII. PUBLICATIONS

PAPERS PUBLISHED DURING 1937-38

1 Bose, R. D. . . . Improved Pusa oats for fodder production. *Agri. and Livest. India*, 1938 : 8 : 245-49.

2. Deshpande, R. B. . . Studies in Indian fibre plants. No. 5. Further studies on the inheritance of certain characters in *Hibiscus sabdariffa* L. *Ind. Jour. Agri. Sci.*, 1938 : 8.

3. Deshpande, R. B. and Mallik, A. K.. . . Studies in Indian oilseeds. No. 6. Some correlations between oil-content and other characters in the Pusa linseed hybrids. *Ind. Jour. Agric. Sci.*, 1937 : 841-48.

4. Pal, B. P. . . . . The search for new genes. *Agri. and Livest. India*, 1937 ; 7 ; 573-78.

5. Pal, B. P. . . . Milling and baking qualities of two new Pusa wheats. *Ind. Jour. Agri. Sci.*, 1938 : 8 : 153-60.

6. Pal, B. P. and Alam, N. . The effect of certain external factors upon the manifestation of hybrid vigour in wheat. *Proc. Ind. Acad. Sci.*, 1938 : 7 : 109-24.

7. Pal, B. P. and Tandon, R. K. Types of tobacco leaf-curl in Northern India. *Ind. Jour. Agri. Sci.*, 1937 : 6 : 363-93.

Joint paper with the Mycological Section

8. Mundkur, B. B., Pal, B. P., and Nath, P. . . Relative susceptibility of some wild and cultivated potato varieties to an epidemic of Late Blight at Simla in 1936. *Ind. Jour. Agric. Sci.*, 1937 : 7 : 627-32.

VIII. PROGRAMME OF WORK FOR 1938-39

(*i*) Continuation of the breeding and genetical work, with special emphasis on disease resistance and quantitative characters respectively.

(*ii*) Study of heterosis and vernalization.

(*iii*) Study of self-sterility with special reference to the oleiferous Brassicae.

(*iv*) Maintenance of crop collections.

REPORT OF THE SUGARCANE EXPERT

(T. S. Venkatraman)

I. GENERAL

The Assistant Sugarcane Expert, Mr. K. Krishnamurthi Rao, retired on superannuation on the last day of the year after over thirty years of service, a quarter century of which was at the Station. I wish to place on record the services rendered by this officer, particularly during the very long probationary period of the Station.

II. SUGARCANE BREEDING *

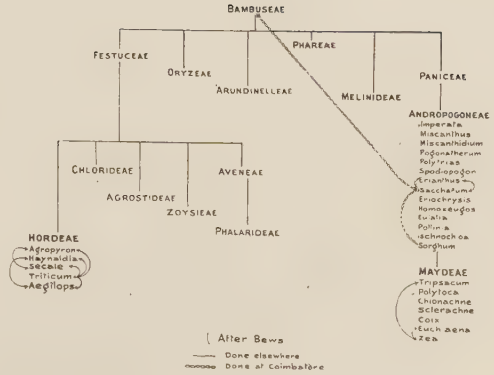
1. General

The early releases from Coimbatore rapidly won their way into cultivation on account of their superior performance over existing canes primarily in the matter of tonnage, such increase often working to between 50 and 100 per cent. It was this increased tonnage that enabled the Tariff Board of 1930 to justify protection to the industry on the basis of the needed raw material being available in the country. The spread of the heavy yielding Coimbatore canes coupled with the rapid development of the factory industry during the first half of the present decade is throwing up fresh problems for the Indian sugarcane breeder.

Problems ahead.—In the pre-tariff days the cane crops which consisted largely of indigenous sugarcanes were relatively poor in growth and somewhat scattered in cultivation. These have since been replaced by the heavier yielding Coimbatore types which are grown in large blocks or supplying the white sugar factories that have since come into existence. This change has incidentally and inevitably resulted in a larger and more contiguous supply of host material for pests and diseases, thus enhancing facilities for their appearance and spread. One such is the *Pyrilla* which, in less than the last half-a-dozen years, broke out in an epidemic form on two occasions, particularly in West United Provinces and South-East Punjab. Also, the incidence of such pests attracts greater attention these days because of the larger and more vocal interests connected with the factory industry.

The organisation of a modern factory with its large outlay of capital and location at one central place involving the movement of canes to the factory (in place of the *gur* manufacturing outfit that could and often does move to the cane fields) is throwing up other problems for the sugarcane breeder. There is now a more pronounced demand for distinct classes of canes—"early", "mid-season" and "late"—to suitably feed the factories during the different periods of the cane-crushing season. Quite recently also the factory interests have been attaching increasing importance to the quality of canes brought to the mill yard. The relative keeping qualities of canes during transport and the periods during which the varieties maintain their quality subsequent to ripening are certain of the other problems which the future sugarcane breeder of India has to tackle. The industry, after establishing itself on the needed raw material made available to it through the increased

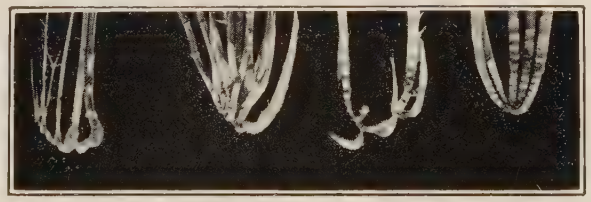
* Breeding work with special reference to tropical types is described in Section V.



Saccharum officinarum crosses with

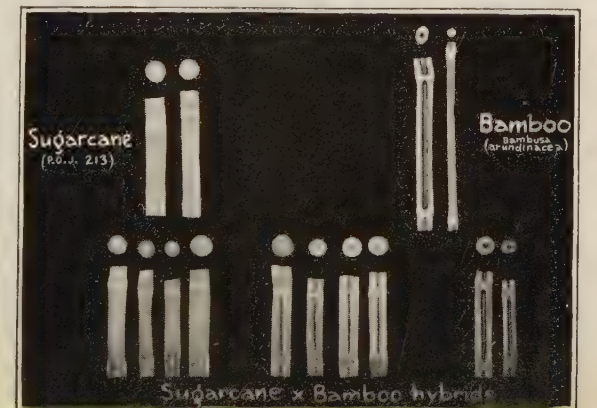
1. Sorghum halepense
2. Sorghum Durra Stapt
3. Sacch : spontaneum
4. Sacch : barberi
5. Sacch : arundinaceum
6. Bambusa arundinacea and others

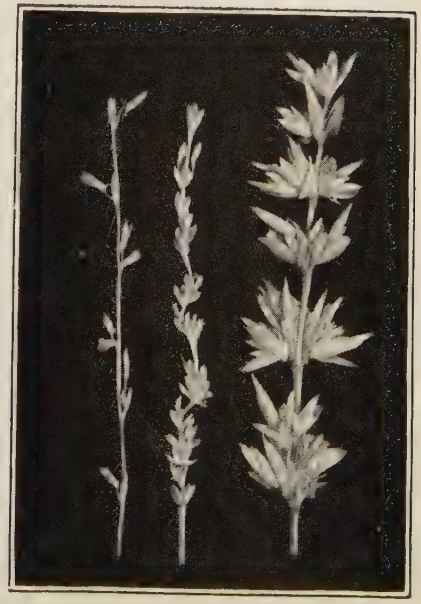
Saccharum hybridizes with distant and widely differing Genera and Species



←Ground level

Bamboo — P. O. J. 213 × Bamboo — P. O. J. 213





Inflorescence of P. O. J. 213 — P. O. J. 213 × Bamboo

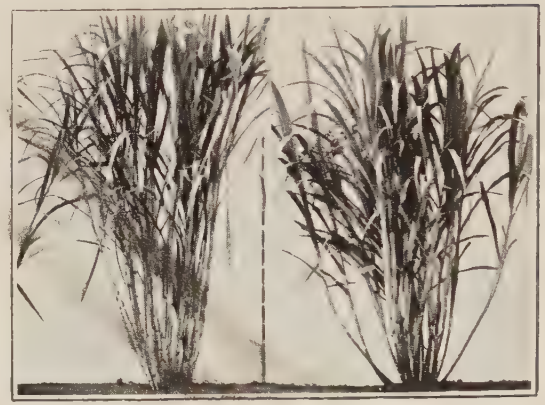
Hollow Stems and inflorescence

P. O. J. 213 P. O. J. 213 × Bamboo (F_2)

P. O. J. 213 × Bamboo (F_2).

Certain Hybrids show Long-jointed, Straight and Erect Canes and heavy tillering

Co. 213 Co. 281



P. O. J. 213 × Bamboo (F_2)

THE F_2 (P.O.J. 213 × BAMBOO) INCLUDES TYPES SUPERIOR TO CERTAIN PRESENT COIMBATORE STANDARDS

PLATE V

yields from Coimbatore canes, may now be said to be entering on the second stage in its development where other characters, besides quantity, are desired in the new productions.

The breeding programme.—The programme of breeding at the Station has been alive to the above changes and continuously adjusting itself to the needs of the industry. Marked attention is being paid of late to the type of seedlings produced by the different parents with reference to the various characters desired by the industry. The scheme of interspecific hybridization is continuing to reveal further possibilities; a very early maturing type was recently obtained from an interspecific hybridization.

New venture.—A new line developed within the last half-a-dozen years has been the constant endeavour to bring in new *genes* through intergeneric hybridization with *Saccharum*, and the successes so far obtained in the crosses effected have been beyond earlier expectations (Plate V). The period that has elapsed since this line was commenced is too short to definitely opine on the economic possibilities of this venture, but evidence is accumulating to indicate that the introduction of the *Sorghum* parent has brought in certain useful characters. The Sugarcane-Bamboo hybridization, which is yet only two years old, covers a much wider gap in the plant kingdom and certain of the F_2 plants are distinctly promising in vegetative characters. Besides the above, there are others waiting to be reported. There is little doubt that a new line of attack in sugarcane breeding—the special feature of which is the introduction of *genes* not available in *Saccharum*—has been opened up by such work.

2. Sugarcane × Bamboo hybrids

The breeding technique.—The difficulty of securing viable bamboo pollen at the right time continues to be a serious handicap in this hybridization. Not only does the bamboo (within reach of Coimbatore) flower later than the peak arrowing season for sugarcanes at the Station, but the viability of such pollen is found to vary according to the position of the spikelets and the prevailing season.

This is being sought to be overcome through the importation of certain bamboos from Bengal reported to flower there every season. Yet another device that has been adopted with some success is the importation of stumps obtained from bamboos in flower and planting them at Coimbatore. Certain of these have continued to flower after their shift to Coimbatore for the last three months.

The F_1 and F_2 generations.—The plants of the F_1 generation secured last season have been kept standing in the plots to observe their behaviour in subsequent years. The bamboo being a perennial, it was thought possible, that some of the hybrids may continue to grow and form canes beyond the first season. Certain of the F_1s are behaving in this manner and producing fresh shoots further away from the clump.

It is fortunate that certain of the F_1 hybrids proved fertile and set seed freely. This has enabled this hybridization to be carried on to the F_2 generation even in the second year. Nearly 1,000 of such hybrids are now growing in the plots, and the plants are proving of great interest both from the scientific and economic view points.

Influence of bamboo parent.—The F_2 plants show in a marked degree the characteristics of the bamboo. One of the prominent characteristics of the bamboo stem is its central cavity. The F_2 plants show this character markedly in about 20 per cent of their number. The distribution and arrangement of the spikelets in the hybrid inflorescences also indicate the influence of the bamboo parent. The hybrids show a large number of abnormalities usually associated with such markedly distant hybridization.

P. O. J. 213 had been employed extensively as mother parent in the routine breeding work at Coimbatore, and popular canes like Co. 213 and Co. 281 are of this parentage, being crosses between P. O. J. 213 and other *Saccharum* species. Though literally thousands of seedlings from P. O. J. 213 had been raised in the past, the populations did not show any types similar to the parents of P. O. J. 213, *viz.*, Black Cheribon of Java and Chunnee of India. Crossed with the bamboo, however, types very similar to both Cheribon and Chunnee, as well as other types not usual in *Saccharum* hybrid populations, are showing themselves in the F_2. This is interesting, as apparently this wide hybridization thus throws light on the genetic composition of the mother parent.

Possible economic results.—Habit of cane is an important economic character in the field, and one of the characteristics of P. O. J. 2878, for which it has gained a deserving reputation, is its tall, straight, erect canes. As is well known, the bamboo possesses this character in a marked degree. The F_2 generation includes plants which show this desirable character.

The bamboo rhizome has a tendency to dip down in the earlier stages and grow underground, thus carrying the new shoots away from the mother stem. The sugarcane is characterized by a closer tillering than the bamboo. Through a probable combination of the characteristics of both the genera certain of the F_2 plants are showing very marked tillering power. As profuse tillering has a direct bearing upon tonnage the advantage is obvious.

The F_2 generation plants contain types which are obviously of no economic value on account of disadvantageous characters, like early shooting of buds, hard rinds and hollow stems which only serve to bear evidence of the hybridization. There are others, however, of obvious economic value as indicated above.

One character associated with inheritance of characters in hybrids with sugarcane as mother parent, is the very wide variation that is available in the resultant population. As the subsequent multiplication of the improved seedlings is through vegetative propagation, the useful characters for which the new canes are selected are kept practically intact in the subsequent crop. The F_2 generation of these bamboo hybrids shows a similar behaviour, as a result of which it might be possible ultimately to secure useful types from adequately large sized populations. A batch of 200 seedlings of P. O. J. 213 $\times$ Bamboo (F_2) contains a few seedlings which are distinctly superior to the standard canes of Coimbatore like Co. 213 and Co. 281 in vegetative characters. The preliminary refractometer readings have been very encouraging.

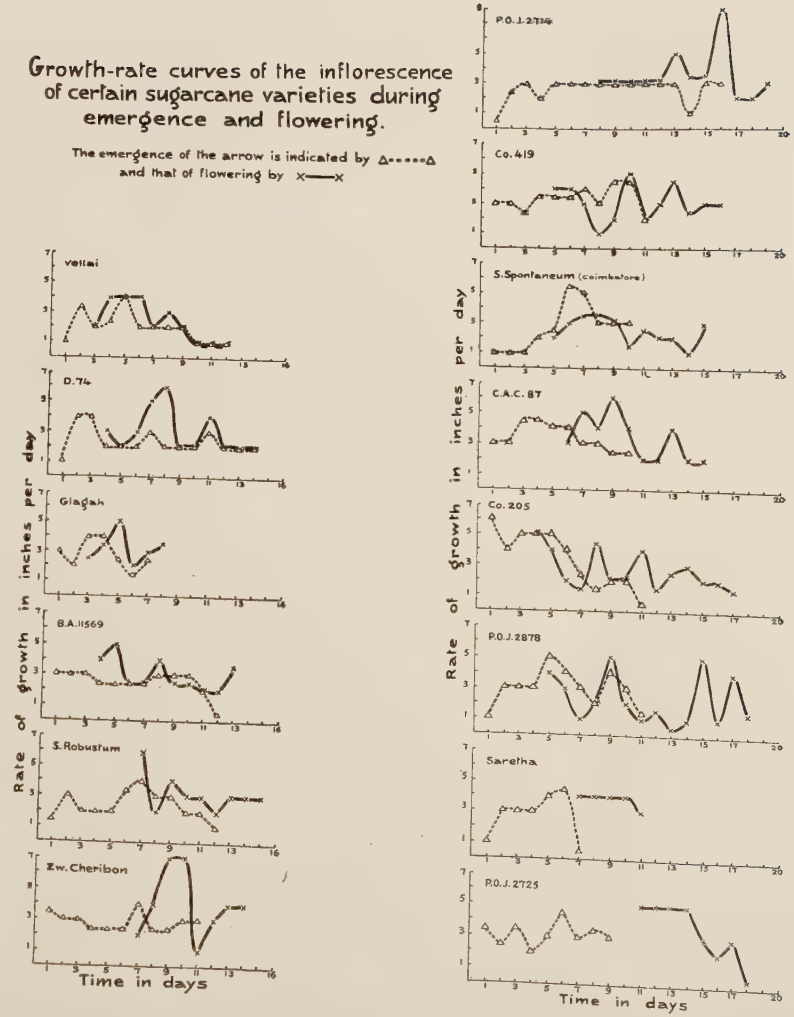


FIG. 1. Graphs showing arrow emergence in relation to flower opening in certain sugarcane varieties.

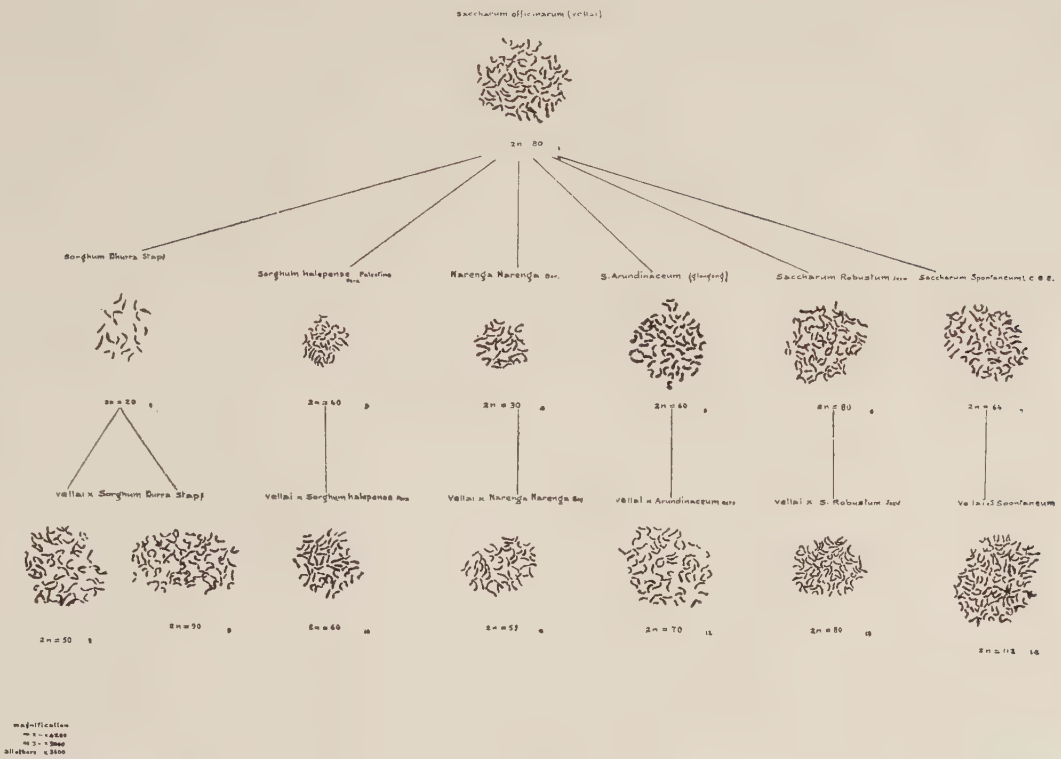


FIG. 2. Chromosome complex of *Saccharum officinarum* (Vellai 2n=80) and those of some of the species with which it has been crossed at Coimbatore. The lowest row shows the chromosome complex of the hybrids. The numbers indicate that either the full haploid (n=40) or the full diploid (2n=80) complement of Vellai is transmitted to the offspring together with the haploid of the male parent.

PLATE VI

3. 'Late' canes

The attempt to breed 'late' canes by crossing with *S. arundinaceum* mentioned in the last report has shown a handicap in that the hybrids rarely flower. It is still hoped, however, that some of them might arrow freely during the later years of vegetative propagation, as has been the experience with the Sugarcane × *Sorghum* hybrids. However, the test plots during the season have shown on analysis a fair number of late maturing types among the interspecific *Saccharum* hybrids. These have been obtained by breeding between themselves Coimbatore seedlings which had shown themselves to be 'late'.

4. Parents

The Burma *S. spontaneum* which itself possesses considerable vegetative vigour has yielded a seedling with almost ideal vegetative characters. Co. 421 is proving increasingly useful in the breeding of vigorous growing seedlings. Other useful parents are Co. 312 for vigour, Co. 354 for early high sucrose and Co. 349 for vigour and habit. *S. robustum*, reported useful in breeding the 'Noble' type of canes in Hawaii, would appear to need further crossing with types of *S. spontaneum* to increase vegetative vigour.

III. * CYTO-GENETIC STUDIES

Chromosome studies of the comparatively simple hybrids mentioned in the last report have thrown some light both on the genetic composition of certain canes and also on the mode of inheritance in *Saccharum*. New hybrids effected between *Saccharum* and other genera have indicated the probable phylogenetic relationship of *Saccharum* with other grasses.

The cyto-geographical survey of *S. spontaneum* in the country was extended to forms from Assam, Orissa, the United Provinces and the Northern Circars of the Madras Presidency. From a chromosomal study of the root tips of the *Saccharum* × *Bambusa* hybrids it was predicted by Dr. E. K. Janaki Ammal, even during the early stages of growth, that their flowers would be fertile and their subsequent flowering has confirmed this finding.

Other results of some interest are mentioned below :—

(1) In general, association of chromosomes at meiosis in the intergeneric hybrids between *S. spontaneum* and *Sorghum Durra* was confined to those of the same genera and differences in rate of condensation and movement of chromosomes were observed in these hybrids.

(2) In the absence of true homologous pairs remote affinities were expressed by multivalent association of chromosomes in intergeneric hybrids.

(3) "Triploid" hybrids (arising by the fertilization of 2n gametes) between *S. spontaneum* and *Sorghum* were found to be more fertile than the "diploid" (arising by the fertilization of n gametes).

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* The work described in this section is financed by the Imperial Council of Agricultural Research, and is under Dr. E. K. Janaki Ammal.

(4) As P. O. J. 2725 has been frequently used as mother at the Station a study of its meiosis and a chromosome survey of its seedlings, was taken in hand.

(5) The cane Vellai (2n=80) crossed with different parents showed interesting results. The F_1 plants had either (*a*) the sum of the haploid of the two parents or (*b*) the sum of the diploid number of the Vellai *plus* the haploid number of the male parent. (Plate VI, Fig. 2).

IV. OTHER INVESTIGATIONS

1. Fodder canes

Sorghum halepense was successfully crossed with *Saccharum* in the attempt to produce canes useful as fodder. The hybrids show the soft leaves of *S. halepense* and very early flowering (in three months), but the vegetative vigour is far from satisfactory. These will need to be further crossed with *Saccharum* and other parents to introduce growth vigour.

2 Striga in cane plots

The application of silt from tanks recovered from prickly pear through the destructive action of the Cochineal insect is showing some Striga infestation in the particular fields. Apparently the seeds must have been carried to the tank by flood water passing through *Sorghum* fields where Striga is not uncommon. Forming a cup-shaped depression round each Striga plant and filling it liberally with a 10 per cent solution of copper sulphate is found to kill the whole plant. Weaker solutions used on previous occasions failed to kill the plant right to its base. It would appear easier to fight this pest in its plant stage as the seeds are both hardy and long lived.

4. Juice studies

The periodic analysis brought out once again the marked keeping quality of Co. 508 which maintained its juice at practically the same level for full three months. A similar quality in certain Sugarcane × *Sorghum* hybrids has been mentioned in previous reports. Among canes liable to arrowing Co. 281 proved useful in this respect.

5. Fibre studies

Periodic fibre determinations showed that the physical condition and stage of development has an influence on juice extraction apart from quality of the fibre. The tops of canes, for instance, retained more juice than the bottoms though the latter register greater quantity of fibre.

V. SUGARCANE BREEDING (MAINLY TROPICAL TYPES)*

1. Hybridization

In the last report mention was made of Co. 419 and Co. 421 as representing two of the different types that are kept in view in the breeding of the thick class of canes. During the year under report seventy-eight crosses were effected, of which the following three were made on a bulk scale :—(1) P. O. J.

* Carried out by Mr. N. L. Dutt, Second Cane Breeding Officer.

2878 × B. 3412, (2) Co. 419 × 247B, and (3) Co. 417 × K. Boothan. All the above three are for producing the Co. 419 type of seedlings. For the production of seedlings of Co. 421 type the undermentioned two crosses were effected on a semi-bulk scale :—Co. 421 × Co. 411 and Co. 421 × Co. 432. The crosses P. O. J. 2878 × Co. 508, Striped Mauritius × Co. 508, Co. 403 × Co. 508 were made on an experimental scale to see if 'early' seedlings are obtained. Co. 440 has given indications of being a useful ovule parent for the production of 'early' canes. Vellai crossed with Co. 243 has given 'late' canes.

2. Seedling and Test Plots

On the basis of growth, habit, and brix characters as many as 932 seedlings were selected for trial in the Test Plots. This is a record number of selections, being twice that selected during any previous year. The large number of selections have been obtained not due to any relaxation in the rigid standard of selection, but to certain very promising seedlings being available from a large number of crosses. Over thirty seedlings have found a place in the "early" test plots, while twenty-five seedlings, are in the "late" plots. A feature of this year's test plots is the addition of a separate plot for such seedlings as are likely to be useful as chewing canes. Twenty seedlings are being thus tried against the standard chewing canes.

Eleven seedlings have been raised to the status of Co. canes and distributed to the various Provincial Sugarcane Research Stations for trial. The canes are Co. 446 to Co. 456. Their parentages are given elsewhere in this report.

3. Seedlings from different crosses

Twenty-five crosses were studied this year for the type of seedlings yielded by them. The following crosses have given seedlings of a desirable type :—

Co. 417 × Co. 413.
Co. 417 × P. O. J. 2878.
Co. 360 × Co. 413.
Co. 360 × Co. 408.
Co. 400 × Co. 290.
B. 3412 × Co. 413.

4. Arrowing and flower opening

A careful record of the details of flowering of nearly 200 varieties has shown interesting results. The time taken by the arrow to emerge fully and the relation of arrow emergence to flower opening were recorded. On this basis it was found that sugarcane varieties are divisible broadly into three classes. Firstly, those like Vellai or Otaheite in which the flowers begin to open almost as the arrow emerges, and secondly, those like Zwart Cheribon in which the flowers do not commence opening till about half of the arrow has emerged. Most of the sugarcane varieties fall under this second class. To the third category belong varieties like P. O. J. 2725 and Saretha in which the flower opening commences only after the arrow has emerged almost fully. These classes are shown in the accompanying graphs (Plate VI, fig. 1). As regards opening of spikelets those of *S. spontaneum* are the earliest to open

and remain open for about an hour. The spikelets of *S. officinarum*, on the other hand, open relatively late and remain open for four to five hours. In Uba, Saretha, and Co. 205 the spikelets remain open for two and a half to three hours.

In the varietal plot. 150 varieties flowered during the season out of a total of 218 varieties. The varieties Pyinmana Red, Port Mackay Noir, and Namam flowered for the first time at the Thick Cane Area. The spikelets of Pyinmana Red are sterile as the essential organs are indistinguishable and reduced to a pulpy mass.

Observations during the year confirmed the previous observation that if there is wind before the usual time of flower opening, the opening of spikelets and the dehiscence of anthers is hastened by more than an hour. This was particularly so in the case of good pollen producers like S. spontaneum (Coimbatore) and Co. 285.

5. Photo-periodism

To study the effect of extra illumination Co. 213 and Co. 421 in wet land were given extra illumination by means of a 100 watt lamp. The treatment was started in June and the plants received 777 hours of extra light. The effect was that the majority of the clumps failed to flower. A new plot has been laid out with Cos. 213, 285, 421 and P. O. J. 2725 repeated six times. Each replication will receive only 250 hours of illumination with four 60 watt bulbs but at different stages of growth starting from March when the plants will have been one month old.

6. Fourth Glume and Palea

The IV Glume was studied in a number of sugarcane varieties. It was occasionally found to possess an awn in the following varieties:—Co.'s 213, 214, 381, 508, 526, 527, 531, and P. O. J.'s 2875 and 2887. The IV Glume was also occasionally present in Purple Mauritius, P. M. Noir, Puri and Creole but without the awn. The IV Glume was also examined in a few Sugarcane × *Sorghum* hybrids.

The size and shape of the palea was not found to be constant. It varied even in the same variety. In the *S. officinarum* varieties there is tendency to deep forking which becomes so deep in certain cases that two separate parts of the palea can be teased out.

7 Length of filament

An attempt was made to measure the length of the filament during the opening of the spikelet. Observations on eleven varieties go to show that the maximum elongation takes place in certain varieties in about twenty minutes, while in others it takes about forty-five minutes. In many of the spikelets of Striped Mauritius and P. O. J. 1499 the filament was found to remain twisted inside the spikelet. The filaments of Zwart Cheribon, Striped Mauritius and P. O. J. 2727 are short, while those of Glagah and *S. Spontaneum* are long, being almost twice the length of the former.

8 Male nuclei

In the course of the study of the artificial culture of pollen—a study which is now a routine feature at the Station for the new canes—curved male nuclei were noticed in Co. 529. Such curved nuclei are not common in the varieties so far studied except in B. 3412 where spiral male nuclei are occasionally met with.

VI. WORK AT THE KARNAL SUB-STATION *

1. General

The year under report is the seventh year of the Sub-station. The extension of area mentioned in the previous report enabled facilities being offered to the Imperial Mycologist and the Imperial Entomologist for their studies on the relative resistance of cane varieties. The addition of the Technical Assistant rendered it possible to follow the changes in juice quality in some detail.

2. Diseases

The growth conditions were very unfavourable on account of delayed rains disadvantageously distributed. There was no frost, but the crop suffered from a severe epidemic of pyrilla which, combined with the prolonged drought, affected tonnages and markedly lowered juice qualities.

Field observations showed that Pyrilla incidence adversely affected more the quality of juice than quantity. It appeared as if the pest took hold of the crop at a time when its juice was in an unripe condition and kept the quality at that level. The advantage of early canes came out rather prominently during the year.

Fewer and narrower leaves at the crown and an erect habit of the leaves were indicated as useful against the pest.

3. Results

Co. 395 was definitely indicated as a cane worth extended trial. It is early, withstands drought and possesses both good habit and satisfactory juice quality. Co. 533 is another promising one among the recent seedlings. Co. 285 again showed its value as a fair performer through good and bad years. Certain of the Karnal selections proved to be ' early '.

Owing to the unfavourable seasonal conditions the crops did not yield proper *gur* till the fag end of the crushing season. Consequently, it was not possible to follow up the *gur* values of the different canes through the different periods of the crushing season in the tract.

VII. DISTRIBUTIONS

1. As seeds

Seeds of Co. 421 × Co. 313 and of Co. 421 × Co. 393 were sent to the Economist Botanist, Shahjahanpur, and of Co. 421 × Co. 312 to the Director, South African Sugar Association, Natal. Seeds of P. O. J. 2878 × Co. 331 were despatched to the Director of Plant Breeding, Sydney (Australia).

* The work described in this section is financed by the Imperial Council of Agricultural Research.

2. As seedlings

Three combinations with Co. 421 as mother and numbering over 5,000 were despatched as seedlings to the Sub-station at Karnal after hardening them for the journey.

3. As canes

Over 200 individual packages representing about sixty varieties—mostly Coimbatore canes—were sent to about thirty places in India and one packet to Ceylon.

VIII. PARENTAGE OF COIMBATORE SEEDLINGS

Co. 446 = P. O. J. 2878 × Co. 281.
Co. 447 = Co. 421 × (Co. 281 × Co. 223).
Co. 448 = P. O. J. 2725 × Co. 285.
Co. 449 = P. O. J. 2878 × Co. 331.
Co. 450 = P. O. J. 2878 × Co. 213.
Co. 451 = P. O. J. 2878 × Co. 213.
Co. 452 = Co. 365 × Co. 331.
Co. 453 = Zwart Cheribon × Co. 285.
Co. 454 = Co. 290 × 247 B.
Co. 455, Co. 456 = P. O. J. 2725 × *S. spontaneum* (Coimbatore).
Co. 534 = Co. 349 × Co. 312.
Co. 535 = Co. 213 × Co. 508.
Co. 536, Co. 537 = Co. 213 × Co. 285.
Co. 538 = Co. 213 × Co. 244.
Co. 539 = Co. 354 × Co. 331.
Co. 540, Co. 541 = P. O. J. 2878 × Co. 331.
Co. 542, Co. 543 = (P. O. J. 2725 × Sorghum Durra stapf) × Co. 331.
Co. 544 = Co. 349 × Co. 346.
Co. 545 = Co. 349 × Co. 285.

IX. PERFORMANCE OF COIMBATORE CANES

1. In India

At the desire of the Imperial Council of Agricultural Research, a detailed note was drawn up indicating the present position and performance of different sugar-cane varieties over the whole of India. This note showed the manner in which the Coimbatore canes have been steadily ousting other varieties. It was discovered that in certain of the principal cane tracts the Coimbatore canes had spread to over 90 per cent. of the area. Further encouraging reports have been received about the performance of Co. 312 and Co. 313

from the Punjab and the United Provinces, of Co. 299 from Bihar, of Co. 419 from many parts of tropical India and of Co. 421 from sub-tropical India. Co. 356 from Bihar and Co. 352 from South Arcot in the Madras Presidency—both of which are intergeneric hybrids between sugarcane and sorghum—have been reported promising under certain conditions.

2. In Foreign countries

Both Co. 281 and Co. 290 are proving useful in foreign lands; Co. 301 has recently been added to this list in Natal. Co. 290 was awarded the Grand Prize in Hawaii as possessing the biggest stool ever produced anywhere with 360 canes to the stool standing 30 feet high and possessing two tons of raw material with 400 lb. of commercial cane sugar in it. It is interesting that although Hawaii is so different from Coimbatore in growth conditions, one of its productions should record such a performance in that island of heavy yields.

X. POST-GRADUATE STUDENTS.

Two post-graduate students who had taken up the regular two years' sugarcane course of the Delhi Institute—*viz.*, Messrs. S. Madassir Ali, Assam, and P. M. Kholi, Peshawar—completed their one year training at Coimbatore in October and November, 1937, respectively. Mr. S. Ihsan Husain of the Hyderabad Department of Agriculture was given a six-month course to get himself familiar, particularly, with problems associated with varietal testing.

Mr. S. Narayanaswamy, B.Sc. (Hons.), was put on to the study of the "Origin of triploidy in *Saccharum*" which is to form his thesis for the M.Sc. degree of the Madras University. Mr. P. Abraham, M.Sc., Assistant to the Cotton Specialist, Coimbatore, joined on 1st June for training in the latest methods of cyto-genetics. This has been undertaken at the request of the Indian Central Cotton Committee and the Department of Agriculture, Madras. Both the above are taking their training under the Sugarcane Geneticist, Dr. E. K. Janaki Ammal.

XI. MISCELLANEOUS.

The only useful well at the main area has been showing a steadily decreasing water supply, apparently because of the deepening and boring of wells in the neighbourhood. A power drill has been installed to seek a deeper and surer source of water supply.

The shortage of rain during the north-east monsoon and the absence of the usual summer showers resulted in extreme drought conditions, thus greatly delaying the growth of the 1938-39 crop.

An extension to the office and laboratories kindly opened by the Director, Rao Bahadur B. Viswanath, and the installation of telephone connection with the town have been of appreciable use to the Station.

The visitors during the year included His Excellency the Governor of Madras and Lady Marjorie Erskine, the Members of the Sugar Tariff Board, Dr. J. D. Tothill from Uganda and A. G. Beattie from Nigeria, certain of the Foreign Delegates to the Indian Science Congress such as Sir Arthur Hill, Professor Ruggles Gates and Dr. E. M. Crowther.

XII. PROGRAMME OF WORK.

The breeding will be continued with the object of effecting further improvements with special emphasis on the breeding of 'early' and 'late' canes. An attempt will be made to fully exploit the possibilities from the two intergeneric hybridizations effected between the sugarcane on the one hand and sorghum and bamboo on the other.

Studies will be continued on (1) factors affecting seed germination, (2) effect of photo-periodism on cane flowering, and (3) causes of sterility in the sugarcane.

Cyto-genetic studies will be continued on the various species of *Saccharum* and its many hybrids to elucidate the genetic behaviour of *Saccharum*. Certain comparatively simple hybrids specially made by the Geneticist for such studies are now available.

XIII. PUBLICATIONS

1.	Venkatraman, Rao Bahadur T. S. .	The Indian Village—Its Past, Present and Future *Agriculture and Livestock in India*, Vol. VII, Pt. VI, Novr. 1937, p. 702.
2.	Do. .	Hybridization in and with the genus *Saccharum* (Its scientific and economic aspects). Presidential Address at the Indian Science Congress, Calcutta, January, 1938.
3.	N. L. Dutt, M. K. K. Iyer, and K. S. S. Rao.	A note on seed setting and seed germination in certain sugarcanes. Ind. Jour. of Agri. Scie., Vol. VIII, Pt. IV, Aug. 1938, pp. 429—433.
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REPORT OF THE IMPERIAL AGRICULTURAL CHEMIST

(B. Viswa Nath)

I. INTRODUCTION

The functions of this Section of the Institute are (1) post-graduate instruction in Soil Science and Agricultural Chemistry, (2) research and investigation on problems connected with the science and practice of soil management and crop growth, (3) the investigation of the scientific and economic questions involved in the utilisation of agricultural produce and in the disposal of the waste products of agriculture and (4) analytical and advisory work on the chemical aspects of problems under way in the other Sections of the Institute and for others.

With the report for 1936-37, a review of three decades of research on soils and agricultural chemistry was presented. It recorded the directions of steady advance during the past thirty years and indicated the present status of our scientific knowledge of Indian soils and crops and the lines of further work. Although the work in the past has been fruitful in the solution of our agricultural problems and in the development of practical schemes of soil management and crop husbandry, the experience of the past has given rise to several new concepts. We know now that the soil is dynamic and that its future can be visualised from a study of its past, and that it is necessary to distinguish between the processes and their intensity in the temperate and tropical soils and the crops that grow in them. With the understanding of the significance of nitrogen, phosphorous and potassium as major elements in plant nutrition and with the experience gained in the laboratory and in the field many problems of a complicated nature and of great practical value have appeared. It has become evident that studies on soils and studies on manuring and fertilization cannot be considered as separate propositions. The trend of thought and research in the study of growth factors, in providing a microbiological picture of soils in their relation to different crops and the investigations on the energetics of vital processes such as nitrogen fixation and the accumulation of knowledge, which is gradually linking up nutritional quality in foods with soils, call for a sustained programme of work to form the basis for further advance in the evolution of economic practices of agriculture. In the light of the above and having regard to the experience at the central and provincial institutes, a programme of work (appended to the report), which can be put in operation in proportion as facilities and resources become available, has been drawn up.

II. POST-GRADUATE TRAINING AND WORK.

Messrs. A. T. Sanyal (Bengal), P. Mukerji (U. P.) and T. P. Sundaram (Travancore) completed their two-year course at the end of October, 1937.

Messrs. G. Venkatachalam (Madras), M. A. Aziz (N.-W. F. P.), P. Atmaraman (Madras), B. Ramamurty (Madras) and S. K. Mukerji (Bengal) were admitted to the course commencing from November 1936. Mr. Venkatachalam resigned his studentship after eight months to take up the appointment of Research Assistant in the Agricultural Department, Orissa. The remaining four continued their studies and entered the second year course.

Messrs. T. C. Gidwani (Sind), A. Sen (Bengal) and W. B. Sundara Rao (Madras) were admitted to the post-graduate course commencing from November 1937.

Mr. Y. V. Narayanayya, Assistant to the Agricultural Chemist, Coimbatore, and Mr. R. K. Aurangabadkar, Chemical Assistant at the Institute of Plant Industry, Indore, joined the laboratories for short periods of study.

Messrs. M. V. Saradhy, A. T. Sanyal and S. V. Ramanayya were honorary research workers. Mr. Saradhy was working on the problem of varietal differences in plant nutrition, Mr. Ramanayya was engaged on the investigation of anthocyanin pigments in sugarcane and Mr. Sanyal studied soil cultivation in relation to crop yields.

III. RESEARCH AND INVESTIGATION

1. Soils

The work on soils during the year consisted of (1) collation of the existing data and the preparation of a preliminary soil map of India and (2) genetic studies on typical soil profiles.

Soil Map of India.—A preliminary soil map of India was on hand, having for its basis the published work on Indian soils and the unpublished work at the Institute. After submitting it to the Agricultural Chemists and soil workers in India for verification and alterations, the final map will be prepared. The published information is scattered over a number of journals and annual reports and is lacking in data on comparative studies on modern lines. Pending further information from studies, which have been commenced, the basis for the preparation of the map was climatic and colour classification. Using the ratio of mean annual rainfall to saturation deficit of air, the whole of the country could be divided into four longitudinal zones—arid, semi-arid, humid and wet. Each of these zones which runs from north to south and includes many soil types coincides with the geographical distribution of the major crops of the country. Another map was prepared based on colour classification, such as black, red, brown and laterite soils. This classification, though empirical, has been in use for a long time and has carried with it a certain significance in regard to specific characteristics and agricultural practices associated with the soils. The results of soil studies so far made seem to justify this prevalent grouping and classification as a simple but informative one.

Soil studies.—The soil, which is originally the product of interaction between rocks, climate and vegetation, continues to be subject to these influences and assumes characteristic changes in colour, structure, texture, concretions and the consequent physico-chemical and micro-biological properties. Although a considerable amount of valuable data on Indian soils, have been obtained from isolated studies during the past thirty years, there are no data on comparative studies to give a general picture of the present evolutionary status of soils under varied geological and climatic influences that obtain in different parts of the country and to indicate future trends so as to form the basis for the formulation of suitable and more efficient cultural and fertiliser practices. To obtain this information, for defining soil groups and to ascertain to what extent Indian soils fit into the world scheme of soil classification and terminology, a scheme for the study of typical soils has been planned.

Samples of cultivated and uncultivated soils were collected from spots on or adjoining the several experiment stations in different parts of India, on the assumption that each station represented a typical area. In most of the places profile pits did not show well defined horizons. So far twenty-one profile samples from uncultivated areas and fifty-one surface soils from cultivated fields were analysed. A discussion of the analytical results of only fifty per cent. of the samples collected would be premature, but the available data admit certain broad generalisations.

The results in general seem to justify the prevalent grouping and classification as black soils, red soils, brown soils and others. The deductions in regard to the mineralogical origin of the soils, made from the molecular formulae derived from computing the analytical values for the clay fractions, indicate varied geological origin for soils within a group, but show common features in the physico-chemical characteristics of the profiles.

All the black soils so far analysed, although differing in their geological origin, are characterised by their high clay content with high values for aluminium silicates. Under the influence of large diurnal differences in temperature and high saturation deficit, the black soils have developed profiles with such common characteristics as high silica-alumina ratios, high base exchange capacity with relatively high exchangeable sodium and magnesium in lower depths. The red, brown and laterite soils, irrespective of their origin, are characterised by low clay content, low exchange capacity and lower SiO_2-Al_2O_3 ratios. The pinkish soils of the Indus basins and valleys and their tributaries, which are probably derived from granitic syenites or other massive rocks, which yield syenites during the early stages of decomposition, show alkalinity in a more or less pronounced state. Their profiles indicate varying degrees of decomposition, setting free alkali, and iron and alumina moving into lower layers. The soils of the Indus alluvium are rich in alkalis and alkaline earth, those of the Ganges alluvium are relatively freer from alkalis while those of the Brahmaputtra alluvium are highly leached. The low rainfall in the Indus area, moderate rain in the Ganges area and the very heavy rainfall in the Brahmaputra area, are evidently the chief reasons for this effect, although all have their origin in the Himalayan rocks.

The profiles of uncultivated soils in places with low and medium rainfall do not exhibit much variation in apperance, nor do they show great differences in regard to their exchangeable base content from depth to depth. On the basis of exchangeable base content the profiles can be divided into two broad groups those with low and high exchangeable base content. In the arid and semi-arid regions calcium constitutes 70 to 80 per cent. of the total exchangeable bases while magnesium, potassium and sodium together vary between 5 and 15 per cent. In regions with high rainfall the exchangeable calcium is lower at the surface than in deeper layers.

Taking total base exchange capacity, the black soils come out with the highest values, the red with intermediate and the laterite with the lowest values. A feature of the black soil profiles is, that although their exchange capacity is considerably high and uniform in value throughout the profile, characteristic variation is noticeable in the proportions of the exchangeable cations in the profile. Calcium forms the dominant cation in the surface layer. With increase in depth the value for calcium is reduced and that for sodium and magnesium increases. At lower depths the proportion of sodium increases

to a considerable extent. In regard to the depth distribution of water soluble salts, when extracted in the ratio of one of soil to five of water, the profiles fall into five groups depending on the salt content and its concentration in the different horizons.

In regard to organic carbon and nitrogen content, the majority of the soils contain low nitrogen and carbon, the average values being 0·04 per cent. and 0·4 per cent. respectively. The highest organic carbon content so far noticed is 1·2 per cent. and the lowest is 0·3 per cent. The highest nitrogen content is 0·1 per cent. and the lowest is 0·03 per cent. In regard to carbon nitrogen ratio, many surface soils have given values much below ten and far above ten, going as high as 20. Variations occur in the profiles. The ratios are generally high at the surface and become low with depth.

The Cinchona and Clove soil surveys have afforded opportunities for the study of soils at high elevations. They are mostly ferruginous and in some cases laterite soils, which are highly leached, rich in organic matter and with pH values between 4 and 5. In the course of analysis of these soils, it was observed that the values for clay, obtained by the international or other methods of analysis involving dispersion of the clay before carrying out mechanical analysis, did not correlate with field characteristics. While the analysis indicated the soils to be highly clayey the field observations described them as friable loamy soils. Further studies are in progress.

The nitrifying capacities of the cultivated soils from 57 stations were determined using oil-free mustard cake at 30 milligrammes nitrogen per 100 grammes soil at one-third of the moisture saturation capacity of the soils. Some soils showed very defective nitrifying capacity and could not nitrify more than 25 per cent. of added nitrogen in six weeks. On marking such localities on the map it has been observed that they form a strip running east to west, the entire width of the northern strip of Peninsular India and traversing practically all types of soils and climatic regions. The defective nitrification cannot be correlated with any of the soil characteristics so far determined.

Nitrogen Transformations in Soils—Nitrogen Fixation.—Relative to the general studies on soil genetics attention was paid to the study of the mechanism of carbon, nitrogen and phosphorous cycles and to the investigation of the energetics of vital processes such as nitrogen fixation, ammonification and nitrification. One of the lines is the study on the chemical oxidation of nitrogen at low temperatures and its relation to the carbon and nitrogen cycles. It was reported last year that slow atmospheric oxidations are accompanied by activation of nitrogen enabling it to combine with oxygen, yielding oxides of nitrogen or with tin and magnesium forming the nitrides of the metals. Further evidence was obtained during the year under report in support of the above observations. Recent researches on chemical chain kinetics, have established that oxidations, especially oxidation of phosphorous, is propagated by energy chains and by collision with other molecules these chains are broken. But what happens to the energy of these chains is not known. It is possible that the energy is consumed in the formation of other compounds and that oxidation and reduction processes in biological systems involve direct energy transfers. Apart from their theoretical interest in explaining some gaps in our knowledge, the results of the experiments are of theoretical and practical interest to agriculture. The experimental results obtained so far and the work

in progress explain nitrogen fixation in soils in summer months when the temperatures are too high to permit optimum micro-biological activity, throw fresh light on certain problems connected with the energetics of photosynthesis by the green plant and on the problems of nitrogen and carbon transformations in the soil.

2. Manures, Fertilizers and Crops

Do cereal crops fix atmospheric nitrogen in the soil?—A question of considerable theoretical and practical interest, which is being asked often without a satisfactory answer is whether cereal crops contribute to the fixation of atmospheric nitrogen in the soil as is found to be the case with leguminous crops. The work that has been in progress in these laboratories during the past few years has come to a stage at which the accumulated data and the present state of knowledge on the subject can be discussed.

In the year 1929-30 two series of rotation experiments were started at Pusa to test the effect of the rotation of crops on conservation of soil nitrogen. In one of the series the *rabi* (winter) crop in all the plots was wheat with different rotations in the *kharif* (summer) season and in another the *kharif* crop was maize in all the plots with different crop rotations in the *rabi* season. While examining the balance sheet of the nitrogen in the plots in these series at the end of one year, it was noticed that a large surplus of nitrogen was fixed in the soil where maize was sown in the *kharif* (summer) season and to a lesser extent where wheat was sown in the *rabi* (winter) season. This result was contrary to the general belief that crops like maize and wheat could not fix nitrogen in the soil, although statements appeared occasionally on the nitrogen-fixing power of non-leguminous crops.

In 1893, A. Schneider demonstrated that *rhizobia* could be modified to develop to a certain extent in the root cells of maize. In the same year B. Frank believed that flowering plants like oats, buckwheat, brassica and potatoes possessed the power of fixing atmospheric nitrogen. In 1897, Pfeiffer and Franke recognized fixation of nitrogen by mustard. In 1919 Claude showed that cruciferous plants were associated with nitrogen fixing bacteria. In the same year Joshi at the Imperial Agricultural Research Institute showed by inoculation experiments in pots, that maize, oats and wheat were benefited by the legume nodule organisms. In 1922 Lipman and Taylor found that wheat plant fixed nitrogen in pot culture experiments. In 1925-27 Trauffant and Bezsonoff were able to grow maize in nitrogen and carbon free media when inoculated with nitrogen fixing bacteria. They found that root secretions supplied sufficient energy. In 1929 Sen demonstrated association of nitrogen-fixing bacteria with the roots of the rice plant. Since the non-leguminous plants have been shown to influence the nitrogen-fixing organisms in the soil, chiefly by their root secretions, a study of the root secretions of maize was made in the first instance and it was shown by laboratory experiments that maize root secretions after passing through Pasteur Chamberland Filtering Candle (to exclude any addition of bacteria along with the root secretion) increased nitrogen-fixing power of the soil flora by 15·56 per cent. (Vyas, Ind. J. Agric. Sci. *4*, 1934). In the meanwhile, the field experiments in these series of rotations were continued without change and further investigations on the possibility of maize and wheat fixing nitrogen in the laboratory under controlled experimental conditions were commenced.

In the fild experiments, an account of the nitrogen in the soil just before sowing the crop, the nitrogen removed in the harvested crop and the nitrogen remaining in the soil after harvesting the crop in each plot was maintained.

There were sixteen plots with four systems of crop rotations :—

1	Maize	Kharif.
	Barley	Rabi.
2	Maize	Kharif.
	Kerao (*Pisum arvense*)	Rabi.
3	Maize	Kharif.
	Barley and *Kerao* (mixed)	Rabi.
4	Maize	Kharif.
	Kerao	Rabi.
	Maize	Kharif.
	Barley	Rabi.

Maize was the *kharif* (summer) crop in all the sixteen plots irrespective of what the succeeding crop was in the *rabi* (winter) season under different rotations. There were thus 16 plots under maize in the *kharif* season for five years in succession. In the following tables are given a summary of the results of nitrogen balance with the different crops and full data for the maize crop.

Table I

Nitrogen fixation by crops in Pusa soil

Year.	Average gain or loss of N lbs. per acre		
	Maize	Barley	*Kerao* (*pisum Arvense*)
1930-31	107·2±24·4	86·75±44·02	105·00±61·67
1931-32	—9·4±15·4	—29·50±28·47	124·75±15·03
1932-33	—48·3±24·1	—35·25±15·68	29·50±25·02
1933-34	54·1±15·1	24·00±18·74	94·75±26·20
1934-35	96·1±16·1	13·50±21·77	33·50±42·25

Further experiments could not be carried out at Pusa owing to the move of the Institute from Pusa to Delhi after the earthquake. The analyses did not include roots. The details or the maize crop are given in Table II.

In the years 1931-32 and 1932-33 there was loss of nitrogen, but the amounts of nitrogen lost are not statistically significant.

There has been significant gain of nitrogen by the soil after a maize crop. The evidence in favour of maize plant fixing nitrogen would certainly have been stronger had there been a set of plots to determine the extent of fixation by soil alone, but the data obtained with barley obviate this defect. The results with this crop do not indicate nitrogen fixation. On the other hand the results of the *rabi* series of experiments, which are not discussed here and in which wheat was the crop in all the plots followed by *kharif* rotations, also indicate fixation of a certain amount of nitrogen during the growth of wheat. As would be expected, *kerao* (*Pisum Arvense*) fixed nitrogen in all the years but the amounts fixed in the seasons 1931-32 and 1933-34 only are statistically significant.

Since nitrogen gain was found to occur in the soil during the growth of crops like maize and wheat, the next step was to find out whether any nitrogen fixing organisms were associated with the roots of these plants. Small pieces of roots, about 1 to 1·5 inches in length, of maize and wheat were taken at various intervals and their outside surface was sterilised with mercuric chloride solution (1 in 1000) under reduced pressure for five minutes and the pieces of roots were, after washing six times with sterile water, transferred aseptically to a nutrient solution. It was found that growth of an organism occurred after incubation on all the occasions that such isolations from maize and wheat were attempted. The isolates from maize were studied for their cultural and biochemical properties and it was established that the different isolates were one and the same organism and when grown in Ashby's mannite solution fixed nitrogen to the extent of 2 to 3 mgm. per 100 c.cm. The isolates from wheat roots were also found to be a mixed culture of two rod—

Table II

Gain or loss of nitrogen in lbs. per acre under maize.

Samples	1930-31			1931-32			1932-33			1933-34			1934-35		
	In Soil	In Crop	Total	In Soil	In Crop	Total	In Soil	In Crop	Total	In Soil	In Crop	Total	In Soil	In Crop	Total
1	70	24	94	—10	28	18	—130	54	—76	—20	35	15	70	47	117
2	50	25	75	—80	37	—43	..	46	46	—50	49	—1	90	43	133
3	80	31	111	80	36	116	—60	50	—10	—170	45	—125	—50	51	1
4	340	29	369	30	59	89	—170	34	—136	—40	52	12	80	50	130
5	70	27	97	—290	26	—264	70	54	124	..	38	38	50	39	89
6	—60	32	—28	—50	25	—25	—80	40	—40	110	36	146	80	48	128
7	—70	25	—45	—30	26	—4	—150	47	—103	—90	31	—59	110	42	152
8	170	25	195	—20	49	29	—200	38	—162	90	44	134	110	42	152
9	120	21	141	—150	23	—127	80	39	119	120	31	151	..	25	25
10	60	23	83	—130	23	—107	..	41	41	70	34	104	10	47	57
11	250	21	271	40	33	73	—50	47	—3	30	36	66	180	33	213
12	..	31	31	—10	35	25	—290	39	—251	160	42	202	—70	47	—23
13	100	26	126	—50	19	—31	—90	42	—48	—30	26	—4	20	35	55
14	—50	28	—22	—50	27	—23	—60	54	—6	—20	36	16	20	42	62
15	10	26	36	40	35	75	—200	50	—150	50	43	93	160	46	206
16	150	31	181	20	29	49	—150	32	—118	40	38	78	..	40	40
Average gain or loss.			107·2 ±24·4			—9·4 ±15·4			—48·3 ±24·1			54·1 ±15·1			96 ±16·2

shaped organisms which gave different kinds of colonies and could not be separated from each other, but they were different from the maize organism which was a coccus. The cultural and biochemical characteristics of the wheat organism remain to be studied after the mixed culture is separated into its components.

Maize and wheat plants were grown from seeds whose outside surface was sterilised by mercuric chloride solution (1—1,000) for five minutes and washed with sterile water in soil and in sand. The sand was ignited and washed. The results are summarised in the table below :—

	Mgm. total N in crop. Average of six pots	Mgm. N in seed	Mgm. nett N fixed per pot
Maize grown in sand ignited and washed	31·25	12	19·25
Maize grown in Delhi soil . . .	35·93	12	23·93

Pots filled with Delhi soil were kept as fallow and nitrogen fixed in these pots by soil organisms alone (without any crop) was found to be 4·62 mgm. per pot. If this is deducted from the nitrogen fixed in pots with maize, the balance of 19·31 mgm. nitrogen should have been fixed by the maize crop.

The results of growing wheat in sand are as follows :—

	Mgm. total N in crop. Per pot average of six pots	Mgm. N in sand	Mgm. nett N fixed per pot
Wheat grown in sand ignited and washed	28·1	5·0	23·1

The results of wheat grown in soil are not yet available. The above results were obtained by growing maize and wheat in the open air where, besides contamination with dust particles, the plants could utilise combined nitrogen in the air like ammonia and nitrogen oxides. Attempts were, therefore, made to grow maize and wheat in an atmosphere free from dust or combined nitrogen by growing them in jars enclosed in a specially devised apparatus to supply air after passing it through wash bottles containing dilute sulphuric acid and ferrous sulphate solution to exclude combined nitrogenous compounds and to allow only free nitrogen to have access to the plants. The results are given in the table below :—

Plants grown in ignited and washed sand in atmosphere free from combined nitrogen without inoculation	Mgm. total N in crop	Mgm. N in seed	Mgm. N nett, fixed
Maize	20·0	12·0	8·0
Wheat	7·7	3·2	4·5

These results show that even in the absence of combined nitrogen, the maize and wheat plants were able to get some free nitrogen fixed.

Maize and wheat plants were also grown in sand inoculated with cultures of the organisms isolated from maize and wheat roots. Under all conditions of growth, including the growth under aseptic conditions, there was very little difference between the inoculated and the uninoculated jars. Sometimes the inoculated jars showed a very slight increase in the nitrogen fixed, but at other times the uninoculated crop was equal to or better than the inoculated ones. This erratic behaviour may be due to defective sterilisation of the sand

or seed or both and these are under investigation. Field experiments are being repeated at Delhi to see whether the different soil and climatic conditions at Delhi give results similar to or different from those obtained at Pusa. More rigorous laboratory experiments are also under way.

The available evidence is strongly suggestive of the ability of the maize plant to fix atmospheric nitrogen under favourable conditions. What these favourable conditions are is not yet clear; nor can it be definitely stated whether the nitrogen fixed in the soil comes from the free nitrogen in the air or the nitrogen compounds present in the air. Also, the mechanism of the nitrogen fixation by non-legumes like maize and wheat is not quite clear. It is not known exactly, for example, whether this is brought about by the root secretion having effect on the general nitrogen fixing flora of the soil or by a specific organism associated with the roots of the non-legumes or by the combined action of these and other factors which are not yet clear.

Effect of organic manures and fertilizers on the nutritive quality of wheat crop.—The relative nutritive values of wheat (Pusa 52, 1937 crop) grown on the permanent manurial plots at Pusa, under different manurial conditions, were investigated during the year. Grain, grown without manure, with mineral fertilizers and with cattle manure, were tested for the digestibility and nutritive value of proteins by Mitchell's nitrogen balance method, when fed to rats at 5 per cent. protein level. The results are given in the statement below :—

Wheat grain raised with :—	Protein content of grain Per cent.	D. C. Digestibility co-efficient Per cent.	B. V. Biological value Per cent.	N. P. V. Nett Protein value Per cent.
Cattle manure . . .	17·76	94·54	85·09	14·29
Mineral fertilisers . . .	16·98	90·35	81·48	12·56
No manure	17·44	91·32	84·04	13·39

Grain raised with cattle manure has a decidedly higher digestibility co-efficient (D. C.) and a slightly higher biological value (B. V.) compared to the others. The total nett protein value (N. P. V.), which is of the utmost importance in judging the relative nutritive values of food materials, also establishes the decided superiority of the grain raised with cattle manure to the rest. The results point to the fact that the type of manuring not only influences the growth and yield of crop but also its protein make up and nutritive value. These results again confirm the writer's work in India and that of others elsewhere, that manurial treatment and plant nutrition are reflected in the composition and nutritive value of the crop and strengthen the views on the connection between soil fertility and nutritive value of the crop.

Varietal differences in plant nutrition.—Work on this problem was continued with selected wheat strains evolved at the Institute. It is well known that within a specific crop there are different varieties which show marked developmental contrasts when grown under uniform conditions. The variations in qualitative and quantitative characters are so sharp that plant breeders assign distinctive designations to their varieties. The breeder's view is that the genetic composition differentiates the respective performances of varieties under identical conditions, but distinctive physico-chemical and bio-chemical characteristics in the seeds and the seedlings, may also be expected. If these characters could help in determining the requirements and

the efficiency of utilisation of added manures and fertilizers, it will be of considerable practical value in ascertaining the differential requirements of varieties and in formulating their manurial and fertilizer requirements. The plan of investigation has been split into two parts. The first is to study such physico-chemical factors as free and bound water, moisture absorption and tissue hydration and the other is to ascertain the reserves and the requirements of the major elements and see how they correlate. The results of preliminary work indicate no appreciable differences between varieties in the initial absorption of moisture, but in the second period which commences with a sharp break, variations between 50 and 80 per cent. of moisture, were observed between varieties.

Investigations on sugarcane mosaic.—In 1935, Dr. S. V. Desai of this Institute, reported the isolation of an organism from mosaic-affected sugarcane (Ind. J. Agric. Sci. *5*, 1935, part III, pp. 1—20). The main points in Dr. Desai's publication are two : (1) He isolated from mosaic-affected sugarcane an organism with cyclostages, having a filterable stage and a visible bacterial stage, (2) He concluded that mosaic virus was the stable filterable cyclostage of the organism. The first is a matter of technique and what was actually observed and should, therefore, be reproducible ; the second is a matter of interpretation with which others may or may not agree.

During Dr. Desai's temporary absence from the Institute, others at this Institute failed in their repeated attempts to isolate the organism described by Dr. Desai. Owing to the shift of the Institute from Pusa to Delhi and the consequent lack of laboratory facilities, it was not possible to re-examine the subject. Soon after the re-establishment of the laboratories at Delhi, Messrs. N. V. Joshi and S. C. Dutt of these laboratories took up the investigation independently at first and later in collaboration with Dr. Padwick, the Imperial Mycologist, on his arrival in December 1937. The scope of the inquiry was restricted to the answer to the questions whether an organism or organisms could be isolated from mosaic-affected sugarcane and whether such organism or organisms had any cyclostages at all in general and the filterable cyclostage in particular. The question of the identity of the mosaic virus with the filterable cyclostage was considered not relevant to the inquiry as the main finding itself was under doubt and, besides, the identity was concerned with the interpretation of the experimental results.

The results of the re-investigation by Messrs. Joshi and Dutt have confirmed Dr. Desai's results and have traced the failures to the quality of the filter candles and to the season. Having regard to the circumstances under which failures can occur, it is desirable to discuss in some detail the work done so far.

Isolation of cultures from sugarcane tissue.—The technique consisted in putting sugarcane stem tissue after sterilising and washing with sterile water on to an agar slant. The portion of the stem as near to a growing point as possible was selected and cut in lengths of half to one inch and put in sterilised test tubes. Mercuric chloride solution (1—1,000) was poured on the sugarcane pieces and the tubes with the sugarcane pieces and mercuric chloride solution were placed in a filter flask attached to a water pump which produced a vacuum and removed air bubbles. After about 10 minutes sterilisation, the flask was detached, the pieces washed with sterile water several times and then lifted with sterile forceps and placed on agar slopes and incubated at

30°-32°C. Any growth on agar appearing from one to five days' incubation was rejected as due to contamination, but growth appearing after a week or fortnight were sub-cultured on agar and in broth. The sub-culture on agar was later examined for biochemical reactions by inoculating in different media, *e.g.*, peptone broth, various sugar peptone broths, nitrate broth and litmus milk.

To test whether the isolates from the tissue contained filterable forms, the sub-cultures in broth were filtered through L_3 candles (previously tested by the positive pressure method (Aseshov *et al*, Ind. J. Med. Res., *20*, 1933, pp. 1101-88) and a watch was kept on the growth appearing in this first filtrate and no further transfers or filtrations were attempted in order to reduce the possibility of contamination through subsequent handling and opening of the cotton wool plugs.

It is obvious that the L_3 filter candles used in filtering the cultures must affect the results of such investigations. It is important to exercise care in the selection of candles used for filtering by testing them for soundness before using them for filtration. The necessity and importance of some standard method for testing the candles before filtration is self-evident. The positive pressure method, which is usually recommended for the purpose, was employed and consisted in pumping air into candles immersed under water and noting the pressures at which sound candles allow air to escape. The pressure at the first appearance of the air bubbles was noted. If air bubbles appeared at less than 18 lbs. and above 22 lbs. pressure the candle was rejected.

Cultures from sugarcane leaf juice filtrates.—The technique consisted in filtering the cane leaf juice through L_3 candles, which were previously tested by the positive pressure method and then sterilised in the autoclave, and waiting for growth in the filtrate. If and when growth appeared it was sub-cultured on agar and broth, and the sub-cultures were tested for biochemical reactions by inoculating into different media and for filterability by passing through L_3 candles and observing appearance of growth, if any, in the filtrates. Every time the examination of the mosaic sugarcane was made, the healthy sugarcane was also similarly tested for comparison as control.

The technique outlined above is in certain respects different from the one employed by Dr. Desai. There were several reasons for adopting in our investigation a different technique. Firstly, negative results were reported by using Desai's technique and hence it would have been a waste of time and energy to follow the technique. Secondly, the main object of the re-investigation was the isolation of organisms, if any were associated with sugarcane mosaic and not the correctness or otherwise of the technique followed by any worker. Thirdly, the technique adopted by Joshi and Dutt reduced to the minimum, chances of contamination during the isolation of the organism. The only disadvantage of this technique was that the hydrogen-ion concentration (pH 7·8) of the media used reduced the chances of observation of visible bacterial growth in the filtrates because, this hydrogen-ion concentration (pH 7·8) which is favourable for dissociation of the bacteria is to a certain extent favourable also for the stabilisation of the filterable forms. That is, the filterable forms would frequently remain as filterable forms and not revert to visible growth, so that at times the broth filtrate would remain clear even though it might contain stabilised filterable forms.

The following cultures were examined in the course of this investigation :—

1. Five broth cultures sent by the Plant Pathologist for Sugarcane Diseases.
2. One sugarcane tissue culture sent by Dr. Desai from Lyallpur to the Director of this Institute.
3. Forty agar culture tubes from sugarcane stem tissue isolated by Joshi and Dutt (20 from healthy and 20 from mosaic) of which, however, only 18 cultures giving bacterial growth were examined for biochemical reactions and some for filterability.
4. Ninety-two leaf-juice and broth filtrates (46 from healthy and 46 from mosaic) of which 19 giving bacterial growth were examined for biochemical reactions and for filterability.

From the broth cultures sent by the Plant Pathologist (which were sub-cultures from the original mosaic cane tissue culture sent by Dr. Desai from Lyallpur), which were not pure, but mixed cultures, two groups of organisms were isolated. The organisms in the first group consisted of rod-shaped organisms giving colonies and growth visible to the naked eye. These formed slight amounts of acid on various agar media and thus differed from the organisms described by Dr. Desai in his paper. One of these organisms has been shown to have a filterable stage. The organisms in the second group gave colonies and growth hardly visible to the naked eye. There was some doubt as to whether these represented a cyclostage of the organisms of the group described above or whether they represented some cyclostage of the organisms described by Dr. Desai, because the G type cyclostage of the organisms in the first as well of Dr. Desai's organism were very similar. Considering, however, that these G type organisms were present both in the 1st and the 11th sub-cultures, while the other visible stage cultures were present in the 5th and 6th cultures, there is a greater probability of the G type organisms being the same as the organism described by Dr. Desai.

From the culture from the tissue of mosaic sugarcane sent by Dr. Desai an organism was obtained which is believed to be the same as the third or visible bacterial cyclostage as it agreed in all the biochemical reactions given by Dr. Desai for the visible bacterial cyclostage.

In regard to sugarcane stem tissue cultures the appearance of growth of an organism or its absence in the stem tissue cultures is given in the following table :—

Kind of tissue	No. of cultures	Growth of organisms		Absence of growth indicating sterility
		Bacterial growth similar to Dr. Desai's	Growth of organisms other than Dr. Desai's	
Healthy	20	2	4	14
Mosaic	20	16	2	2

It is seen that while a large number of the healthy tissue remained sterile (presumably there was no organism in the tissue) a large percentage of the mosaic tissue cultures gave growth of an organism similar to Dr. Desai's so far as biochemical reactions were concerned. Filterability of only four of these

cultures could be established up to the time of report. The remaining have not yet been completely tested for filterability and on this account although importance may not be attached to the results of the tissue cultures they are still of value when read with the results of sugarcane leaf juice cultures given below.

Kind of leaf juice	No. of sets.	Bacterial growth similar to Dr. Desai's	Growth of organisms other than Dr. Desai's	Absence of growth indicating sterility
Healthy	46	3	9	34
Mosaic.	46	18	2	26

About 74 per cent. of the healthy filtrates remained sterile and about 19 per cent gave growth of organisms other than Dr. Desai's, while about 56·5 per cent of the mosaic filtrates remained clear and growth appeared in 39 per cent similar to Dr. Desai's organism, while only 6·5 per cent of the healthy filtrate also showed growth similar to Dr. Desai's organism. The reason for the apparently erratic results is that the growth of an organism similar to Dr. Desai's appeared in the filtrates only in a particular season of the year and if the results are tabulated according to the seasons, a different picture of the results may be seen.

Kind of leaf juice	Period	No. of sets	Appearance of growth: Bacterial growth similar to Dr. Desai's	Appearance of growth: Growth of organisms other than Dr. Desai's	Appearance of growth: No. growth sterile
Healthy . .	April 37 to June 37 . .	10	1	3	6
	July 37 to Feb. 38 . .	24	0	6	18
	March 38 to June 38 . .	12	2	0	10
Mosaic . .	April 37 to June 37 . .	10	8	0	2
	July 37 to Feb. 38 . .	24	0	2	22
	March 38 to June 38 . .	12	10	0	2

From July 1937 to February 1938 both the mosaic and healthy leaf juice filtrates remained clear or gave growth of an organism other than Dr. Desai's. (This is discussed later on in the report.) It would be expected that healthy leaf juice being free from disease should contain no organism in the filtrate. In regard to growth in mosaic filtrates made between March and June in the two years, they confirm Dr. Desai's original finding. The absence of growth in the filtrates made from July 1937 to February 1938 calls for comment. The non-appearance of the organisms in this period might have been due to two causes. The organisms might have been present in the visible stage and since the candles kept out the bacterial stage, the filtrates remained clear. Or, filterable organisms, though present in the tissue, were stabilised in that stage to an extent that they did not revert to the visible stage during the period between July and the following March.

Either of these assumptions might be correct and the phenomena connected therewith might occur through the influence of the season directly on the life-cycle of the organism itself or indirectly through the seasonal influence on the growth of the plant which in its turn might affect the organism in the plant.

Support for the latter view is lent by the results of an experiment on the growth of sugarcane mosaic visrus *in vitro* and on inoculations of mosaic virus into healthy cane by the Plant Pathologist. He observed that the juice from healthy leaf had an inactivating effect on the mosaic virus. Optimum infection was found to occur at Pusa and at Delhi in the period from March to June, which tallies with the period in which successful cultures of the organisms were obtained from the filtered mosaic juice.

In the light of this information, a critical examination may be made of the results of isolation of cultures from the mosaic and healthy cane leaf juice which may be roughly divided into three sets—1st, from April to June in 1937 ; 2nd, from July, 1937 to February, 1938 ; and the 3rd from March, 1938 to June, 1938. The cultures obtained during April, 1937 to June, 1937 from the mosaic leaf juice yielded organisms which were similar to Dr. Desai's organism from sugarcane mosaic. The attempts were successful on eight out of ten occasions. Of the two unsuccessful attempts there was no growth on one occasion, but on the other hand bacterial growth appeared in the filtrate, but the cultural inadvertently dried up owing to the small volume of the filtered juice. Healthy cane leaf juice filtered through L_3 candles gave growth on four occasions out of ten. On three occasions out of these four, the growth was that of a fungus. This growth of the fungus was considered to be due to outside contamination. The reasons for considering the fungal growth to be due to outside contamination are similar to those given in the next paragraph for filtrates from July, 1937 to February, 1938. On the fourth occasion the growth in the healthy juice filtrate was similar to that from the mosaic cane leaf juice filtrate. Probably the leaf which looked healthy from outside appearance had the mosaic disease in a latent stage.

From July, 1937 to February, 1938 (including both the months) filtrates from cane leaf juice were made on 24 occasions (both healthy and mosaic) and on all occasions the filtrates remained clear except on some occasions when fungus growth appeared. The fungus growth was believed to be due to some outside contamination, because at each time it was different in appearance and it is presumed no fungus spore or mycelium could pass through the candles ; and moreover, on certain occasions, though not on all, their entrance into the tube could be detected to have begun from outside because the spores of the fungus were seen first on the cotton wool plug from which the mycelium was seen entering into the tube before it appeared on the medium. Also, since fungus growth appeared much more frequently in healthy cane leaf juice filtrates than in the mosaic juice filtrates, it was considered that they were not connected with the mosaic affected canes.

From March, 1938 to June, 1938 twelve sets were run in duplicate on different occasions and of these, the results of 10 sets are available. The mosaic filtrates gave growth on all the 10 occasions except in one of the duplicate tubes on one occasion, (*i.e.*, in 19 tubes instead of 20) while the healthy cane juice filtrates gave growth on two occasions out of the 10, and on the other 8 occasions the healthy cane leaf juice filtrates remained clear and no growth of any kind appeared in any of them.

The results of isolations in the two seasons, March to June of 1937 and 1938, are summarised below :—

Kind of leaf juice	Sets in which appeared bacterial growth similar to Dr. Desai's organism	Sets yet to be examined	Sets in which no growth appeared	Total
Healthy	3	2	17*	22
Mosaic.	18	2	2†	22

*Includes three occasions of fungus growth.

†Includes one occasion when bacterial growth appeared but the broth dried up and hence no isolation could be obtained.

Cultures isolated at different times from the mosaic cane leaf juice did not yield the same cyclostage every time, but represented one of the two or three cyclostages. The appearance of a particular cyclostage in the culture is most probably dependent on the season, but there is reason to believe that the period of incubation also has some influence on the appearance of a certain cyclostage in the culture.

The cultures of organisms or rather the different cyclostages obtained gave exactly the same biochemical reactions as described by Dr. Desai for his organism. There was, however, sometimes a marked difference in the morphology. This difference in size is explained by the fact that in these investigations the cultures of the different cyclostages were pure, *i.e.*, included only one cyclostage to the exclusion of the other cyclostages, while Dr. Desai appears to have made his observations with cultures of one prominent cyclostage without completely excluding the other cyclostages.

It is clear that the results of Dr. Desai have been confirmed in that an organism with biochemical reactions and definite cyclostages as described has been isolated from mosaic-affected sugarcane. Dr. Desai carried out his experiments at Pusa chiefly with Co. 213 grown at Pusa, while the repetitions now described were carried out with Co. 213 and other varieties at Delhi and Karnal. It should also be noted that sugarcane tissues from mosaic affected cane at Lyallpur, sent by Dr. Desai, also yielded the organism.

IV. INVESTIGATIONS ON AGRICULTURAL PRODUCE AND INDUSTRIES

Anthocyanin Pigments in the rind of sugarcanes.—Mr. S. V. Ramanayya investigated the pigments of the rind of coloured canes Purple Mauritius, Red Mauritius and Badila (Fiji B). The pigments were obtained in their crystalline form as the oxonium salts of their non-glucosidal form and their physical and chemical properties were under study. On demethylation, they yield their parent bodies in a well defined state. Judging from the tests carried out so far they appeared to be mostly mono-methyl derivatives of delphenidine. Laboratory and large scale factory investigations showed that the colouring matters could be successfully eliminated in the sulphitation sugar factories, without alterations to the existing plant by heavy liming and then using aluminium hydroxide.

Gur Technology.—Some investigations were carried out to ascertain the cause for the development of colour on boiling sugarcane juice in open pans over direct fire. Apart from colour arising from destruction of glucose, tannins and amino-acids appear to account for fifty per cent. of colour development. Paddy husk active carbon has been found in preliminary experiments to eliminate about sixty to eighty per cent. of the colour developing constituents.

Active carbon from paddy husk.—Investigations on the manufacture of active carbon were pursued during the year with the object of cheapening the cost of production which is so essential for its successful use in *gur* manufacture. Besides advising and testing carbons prepared in different parts of the country, the Imperial Agricultural Chemist undertook the guidance of a centre opened near Saharanpur by the Director of Industries to the Government of the United Provinces.

Colostrum investigations.—Experiments were commenced in June to find out whether differences existed in the composition of colostrum of heifers and of adult cows with different ages and number of calvings. The results available so far indicate a high protein content, which generally falls till the time of calving, while the percentage of fat suddenly increases just after calving. The power of colostra to coagulate normal milk appears to be less in the colostrum of a heifer than that of an adult cow.

V. GENERAL CONSULTATIVE AND ANALYTICAL WORK

The following samples were analysed and reported upon during the year :—

Soils	32
Manures and fertilizers	8
Feeding stuffs and fodders	23
Water	25
Sugarcane	226
Milk	15
Syrup, fruit juices, etc.	15
Tobacco and tobacco wastes	11
Oil and wax	3
Miscellaneous	9

Of the soils examined, nine were received from the Agricultural Officer, Baluchistan, 7 from Political Agent, Bahrain (Persian Gulf) and 5 from the Deputy Director of Agriculture, Coorg.

Of the manures analysed mention may be made of the samples of fermented and unfermented mustard cake from the Botanical Sub-Station, Pusa. There was a considerable decrease in the organic nitrogen and P_2O_5 contents in case of fermented cake. Percentages of organic nitrogen and P_2O_5 in " unfermented mustard cake " were 6·15 and 2·43 respectively whereas in case of fermented one it was found to contain 1·47 and 1·04. The nitric nitrogen, however, increased by fermentation and was 0·26 per cent. in case of fermented and 0·06 per cent. in case of unfermented.

Of the feeding stuffs examined, 8 were samples of Limbdi State wheat sent by the Agricultural Marketing Adviser, Delhi. The samples were analysed for moisture, protein and gluten and some physical tests were also carried out.

One sample of dairy nut for feeding cows, received from the Cattle Superintendent, Karnal, was found to contain 6 per cent. oil, 22·5 per cent. protein and 50 per cent. soluble carbohydrate and 121 as " food unit value ", which was fairly high.

Fourteen samples of water were received from the Executive Engineer, Central P. W. D., and were examined as to their suitability for irrigation purposes. Among the water samples, there was a sample of brewery water from Solan Brewery.

For the Agricultural Section, 223 samples of sugarcane juice were analysed periodically (once a month) in connection with the farm's variety test. Most of the samples, which were analysed in early December, were found to be immature—a dozen of them having their purity percentage between 45 and 60. Of the 57 samples examined in January, about a dozen showed marked improvement in their quality while a number of them showed either no improvement or marked deterioration in quality than what was noticed in their examination during early December. The varieties Co. 377, Co. 417, Co. 430, Co. 441, Co. 504, Co. 507 and Co. 508, examined about the middle of February, did not show an improvement on the previous analysis. The varieties Co. 377, 430, 504, 507 and 508, which had shown a set-back at the last analysis in February, made considerable progress in March. Besides the above-mentioned varieties, the following had shown a marked improvement in March :—Co. 213, 331, 366, 368, 371, 377, 425, 426, 434, 506, 510—514 and 516. Varieties Co. 348, 370, 374, 381, 419, 427, 429, 431, 503 and 509 showed no improvement over February analysis.

Of the samples of milk examined, mention may be made of 8 samples of milk received from the Cattle Superintendent of the Institute of an uncovered heifer. There was a change in the composition of the milk during the course of four weeks. The fat content increased from 3 to 4·8 per cent. and the protein content decreased from 5·42 to 3·58. The presence of blood, which was marked in first three samples, came to traces in the last two samples. Four samples of pre-milk from a second calver in calf for 280 days and two from a heifer in calf for 4 months were also analysed. In the case of the former during 36 hours the protein content dropped down from 17·18 to 8·72 and fat content remained as low as 1·2 per cent. In the case of the latter the protein content came down from 10·88 to 7·18 during 24 hours, the fat remaining constant at 1·2 per cent.

Samples of syrup, fruit juices, squashes and jam were sent by the Agricultural Marketing Officer, Delhi, from samples collected by him at the factories at Lyallpur, Baroda and Daurala. Most of the samples were of high quality and conformed to the standards laid down for such products. They were also free from injurious preservatives.

Six samples of tobacco wastes, collected from Guntur, Motihari and Bengal and sent by the Agricultural Marketing Adviser, were examined for their nicotine content.

Of the miscellaneous samples examined mention may be made of a sample of Cassia Tora seed, sent by the Agricultural Marketing Officer, Delhi, and a sample of Hortomone " A " received from the Imperial Economic Botanist. The Cassia Tora seed is used as an adulterant for coffee powder. The fried

powder of the seed resembles coffee, both in colour and smell. The sample of " Hortomone A " which is a root inducing preparation was found to contain the active principle " Alpha Naphthalene Acetic Acid " in cane sugar solution.

Enquiries.—Detailed information on the following investigations and subjects were supplied to various persons and public bodies.

1. Preservation and storage of potato tubers.
2. Preservation of vegetables.
3. Utilization of bones and farm wastes.
4. Suitable methods of making the insoluble phosphate of bone manures available to crops.
5. Production of fine Aroma in butter and cream.
6. A new process for the manufacture of superior jaggery and white sugar by the Open Pan Method.
7. *Neem* cake and *mahua* cake as organic fertilizers.

The Fomana Tobacco Estates, Saharanpur, was supplied with data regarding the chemical and mechanical analysis of typical tobacco soils of Guntur District.

Information regarding the average composition of various cereals and pulses was supplied to the Government Main Experimental Farm, Warangal, Deccan.

The Professor of Animal Husbandry and Dairying, Agricultural Institute, Allahabad, was furnished with a statement giving the yield, composition, etc., of milk of Sahiwal cows and also of Ayreshire-Sahiwal cross-bred cows.

VI. PUBLICATIONS

1. Review on Soil and Fertilizer research for the publication " Agriculture and Animal Husbandry in India "—B. Viswa Nath.

2. The Manufacture of Sulphitation Sugar from coloured canes—S. V. Ramanayya.

3. Chemical oxidation of nitrogen at low temperatures—B. Ramamurty.

VII. PROGRAMME OF WORK

The following is the skeleton programme of work drawn up for the Section for the next few years to be followed as facilities become available.

1. Soils

(*a*) Comparative physical, chemical and microbiological studies on cultivated and uncultivated soils to ascertain the trend of pedogenic processes under the influence of climate and geology and the changes brought about by cultivation and cropping under irrigated and unirrigated conditions.

(*b*) Collation of data and preparation of a soil map of India.

(*c*) Nitrogen fixation and carbon and nitrogen cycles in soils.

(*d*) So far, a considerable amount of attention has been paid to nitrogen whose supplies are available easily and in unlimited quantities by chemical and microbiological methods. The question of soil phosphates, the supplies of which are very limited has not received the attention it deserves. Different forms of phosphorous and its availability in different types of soils, such as alkaline, acid, ferruginous and laterite, will be studied.

2. Soil in relation to plant

(*a*) Different methods of cultivation in relation to crop yields.

(*b*) Draught of bullock drawn implements.

(*c*) Composition and nutritive value of crops as influenced by soil and fertilizer treatment.

(*d*) Cereal crops in relation to soil nitrogen.

3. Manures ahd fertilizers

(*a*) Relative efficiencies of organic manures and mineral fertilizers in relation to moisture availability and soil composition.

(*b*) Possibilities of increasing the efficiency of fertilizers as judged by recoveries in crops.

(*c*) Comparative merits of organic and inorganic manures on crop quality for industrial and food purposes.

(*d*) Varietal differences with regard to fertilizer requirements.

(*e*) In view of the importance of organic matter to soils, the study of the relative importance of organic matter and nitrogen contained in manures and the factors that contribute to the stability and rapidity of the destruction of the organic matter of the manures.

4. Methods

(*a*) Investigation of sampling methods for soils and crops.

(*b*) Comparative studies on analytical methods employed in soil, crop, fertilizers and food analysis, having regard to reliability, cheapness and rapidity. The relative merits of quick *versus* slow methods will also be studied.

5. Utilisation of agricultural produce and agricultural wastes

Every agricultural crop grown needs processing either for preservation or for sale and all produce and waste should be considered as potentially valuable material for industry and trade. The study of the scientific and economic questions involved in the utilisation of agricultural produce and agricultural wastes and the development, where possible, of methods within the ability of the farmer will be of considerable advantage to him. Examples of these are the preparation of jaggery or *gur* from sugarcane and the making of activated carbon from a waste product like paddy husk.

Programme for 1939-40

The major lines of programme for 1939-40 will be—

1. Comparative studies on soils formed under different conditions of temperature, rainfall and evaporation.
2. Studies on carbon and nitrogen fixation in soils.
3. Investigations on the chemistry of sugarcane and manufacture of *gur*.
4. Investigations on sampling and analytical methods.

REPORT OF THE IMPERIAL MYCOLOGIST

(G. Watts Padwick)

I. ADMINISTRATION

Dr. G. Watts Padwick took charge of the Section, which had been held by Dr. M. Mitra, Assistant Mycologist, on November 15th, 1937.

II. TRAINING

Messrs. R. S. Mathur and S. Y. Padmanabhan were admitted as post-graduate students. Mr. N. Prosad continued his studies. Mr. T. B. Lal completed his post-graduate course during the year and was granted his Assoc. I. A. R. I. Mr. Asghar Ginai, Assistant Mycologist for Baluchistan, worked for two months on diseases of fruit trees.

III. DISEASES OF PLANTS

1. Wheat

Loose Smut.—Experiments commenced last year indicated that of forty Indian varieties of wheats tested seven appear to be immune and nine more highly resistant. Infection in the remainder varied from thirty to eighty-one per cent, eleven varieties showing over fifty per cent infection. Healthy plants which had either resisted the smut or escaped the disease have been selected again and heavily infected to observe their performance next year. Forty-seven more varieties, some of which are foreign, have been added in this test.

Bunt.—Studies on wheat bunt were continued. A plot in which wheat was badly infected with bunt (*Tilletia indica*) during 1934-35 was divided into three parts, *viz.*, *a*, *b*, and *c*. Disease-free seed of P.80-5, Punjab 8A and Cawnpore 13 was obtained and sown in *a* during 1935-36, in *b* during 1936-37 and in *c* during 1937-38. In other parts rotation of gram was given. It was noticed last year that the disease is soil-borne as well as seed-borne, and that one year's rotation is not enough. During this year it was found that two years' freedom from wheat reduced soil infection considerably. Wheat seed in the above experiment was again treated with various fungicides, *viz.*, Ceresan wet, Ceresan dry, Agrosan G, Hortisan H, Germisan and Sulphur to see how far disinfected seed when sown in infected soil will check bunt. Each treatment was given six replications. Infection, however, was too low to show any distinct differences between treatments.

It was further observed that plots which were given excess of irrigation showed more bunt, *e.g.*, in a plot of P.165 a part of the plot was irrigated more than the remaining and this had bunt up to 0·5 per cent whereas the remaining part had no disease. In another plot of P.165 in the Sugarcane Sub-Station which was heavily watered the bunt was approximately 1·5 per cent. This confirms previous years' observation that moisture plays an important part in the incidence of this disease.

Flag Smut.—In resistance tests with ninety-seven varieties of wheat twenty-five varieties showed no infection, fifteen varieties showed less than ten per cent and four less than twenty-five per cent. The rest showed infection ranging from thirty to eighty-nine per cent, over twenty-one varieties showing more than fifty per cent infection.

2. Tobacco

Leaf curl.—Experiments to find out a method of artificially transmitting leaf-curl diseases of tobacco have been carried out at Pusa. Non-viruliferous white-flies supplied by the Imperial Entomologist were fed on juice from an affected plant, through Baudrauche capping skins. These flies were later placed on tobacco seedlings raised in an insect-proof cage. Of about 110 treated, two showed very clear symptoms of a mixed type of leaf-curl, five showed slight vein-clearing and others were healthy.

3. Gram

Wilt.—Periodical isolations have been made from wilted gram plants at Delhi and Karnal. A number of isolates of *Fusarium* were obtained, but in all the isolations made one type was predominant. Representatives of all the types isolated were grown in a sterilized mixture of 190 grm. of dry soil, ten grm. of cornmeal and seventy c.c. of water in flasks. After three weeks this mixture was applied to a sterilized soil in layers below and above gram seed. In some cases the plants grew and thrived as well as the uninoculated controls; in other cases seed was rotted in the soil and failed to germinate; but in the case of the *Fusarium* most commonly isolated from the wilted plants, wilt set in when the plants were three or four inches tall and before they were six weeks old not a single plant remained alive (Plate VII). Re-isolations made from the dead plants gave in all cases the original *Fusarium* applied. The experiments were successfully repeated twice.

4. Rubber

Leaf Spot.—It was found that the main cause of spotting of leaves of *Hevea brasiliensis* received from the Mundakayam Valley Rubber Plantation was *Oidium hevae* Steinman. An account of this important disease has been published by Dr. Mitra and Mr. P. R. Mehta.

5. Apples

Fruit Rot.—The effects of temperature and acidity on infection of apples with *Rhizopus arrhizus* Fischer have been worked out. The destructive effect of the fungus on the fruit was well marked from 30°C. upwards, although infection and slight decay could be noted at even 15°C. The fungus preferred an acidic medium for active growth PH 4·1 to 4·4 giving best growth in culture. These findings lend significance to the observation that the fungus is common on the acidic varieties of fruits.

6. Sugarcane

The work under the Scheme for Research on Mosaic and other Diseases of Sugarcane financed by the Imperial Council of Agricultural Research was continued. The detailed annual report is published elsewhere by the Council but a brief summary is given here.

PLATE VII

Effect of infesting soil with *Fusarium* isolates from wilted gram plants on the growth of gram (*Cicer arietinum*)

Pot at left, seed rotting isolate ; centre pot, wilt causing isolate ; pot right, control.

Mosaic.—Experiments at Karnal again showed a considerable reduction in yield with a thick cane variety, namely "Surkha Saharanpuri", the decrease being 18·8 per cent in cane yield, a statistically significant difference.

Little reduction in yield was brought about with the variety Co. 313, in an experiment at the Sugarcane Research Station, Shahjahanpur, conducted in collaboration with the Economic Botanist.

The occurrence of slight secondary infection at Karnal was verified by the appearance of three per cent infection in previously healthy rows of cane growing adjacent to infected plots. Practically no secondary infection occurred in the Tonnage experiment at Shahjahanpur. A similar state of affairs existed at Delhi, where in spite of the fact that there were over thirty cane varieties, healthy and mosaic affected growing side by side, no natural transmission was found to occur.

It has been reported previously that some of the setts from mosaic affected canes give rise to plants absolutely free from any mosaic symptoms and that Co. 313 gave twenty to twenty-five per cent recovery from mosaic at Pusa. No such recovery has been observed in the same variety grown at Shahjahanpur. Mosaic-affected Co. 313 material from Pusa and Shahjahanpur on being tested for recovery shows that while there is fifteen to twenty per cent recovery in Pusa Co. 313 material at Pusa, Delhi and Karnal, there is no recovery in the case of material of the same variety originating from Shahjahanpur when grown at any of these three places. This strengthens the suggestion that the mosaic virus strain affecting Co. 313 at Shahjahanpur is different from that affecting the same variety at Pusa. Inoculations with the leaf juices of recovered plants (Co. 213, 313, 223, 299 and 419) have given no mosaic infection in any of the numerous plants inoculated during the year indicating that recovery is real and is not due to a mere masking of the symptoms of mosaic.

Certain physical properties of the mosaic virus have been further studied. Mosaic leaf juice of M-16, Surkha Saharanpuri, Co. 213 and Co. 313 tested for dilution with maize as test plants, showed that M-16 and Surkha Saharanpuri withstood dilution better than Co. 313, which in turn stood it better than Co. 213. It was found that mosaic juices from several varieties could be centrifuged for half an hour at the rate of 3,000 *r.p.m.* without any appreciable loss of virulence in the supernatant liquid.

The question of the existence of so-called "cyclostage" organisms in connection with mosaic infected canes has been carefully investigated. Organisms were reported to have been isolated for several years from mosaic infected canes and some of these were said to be capable of passing through an L_3 Chamberland filter candle. Attempts to repeat the work on filterability made during the past two years were unsuccessful. The constant failure indicated that in some way the filtering technique employed may have undergone an unintentional change. A careful examination of the records and of the operation of this technique failed to reveal any serious flaws. The original candles used were tested by passing air into them under water and observing the pressure at which bubbles of air arose from the candle. Candles were accepted which bubbled at eighteen to twenty-two pounds pressure. This is a method commonly employed in work with Chamberland filter candles. With the later consignments of candles used since 1936 the method of testing was different, having been based on the rate of flow of a known quantity of water through

the candles under constant pressure. These candles were found not to bubble until over twenty-four pounds pressure. Thus by the different methods of testing the candles a different grade of candle was in fact selected and this may be the explanation for the difference in results obtained at different times with regard to filterability of organisms.

Red-rot (*Colletotrichum falcatum*), *wilt* (*Cephalosporium sacchari*) *and smut* (*Ustilago scitaminea*).—In order to carry out resistance tests against these diseases twenty-two varieties of cane were selected in consultation with the Government Sugarcane Expert.* Results of the smut test are not yet available. The varieties most susceptible to red-rot were Co. 213, 223, 244, 281, 290, 299, 331, 354, 362, 402, 411, 412, 417 ; those more susceptible to wilt were Co. 213, 223, 290, 352, 360, 362, 402, 419 and 421.

Miscellaneous.—Top-rot disease caused by *Fusarium moniliforme* Sheld appears to be on the increase. At Karnal, affected canes Surkha Saharanpuri were marked during July and August and analysis showed that these clumps were lower in sucrose content than healthy clumps.

A species of *Striga* was found to occur abundantly on cane plants in pots at Delhi though no cases of *Striga* were observed in the Farm area from where the soil was obtained for filling the pots.

Cercospera kopkei was found doing considerable damage to cane foliage, especially on thick varieties, at Jorhat (Assam) Farm. The fungus has previously been reported from Burma but not from India.

Cultures of *Cephalosporium sacchari* sent to the Centraalbureau voor Schimmelcultures, Holland, have been identified as *Fusarium moniliforme* var. *subglutinans* (=*Gibberella fujikuroi*). This is highly interesting from the practical as well as the taxonomic point of view.

7. Cucurbits

Anthracnose.—In order to test the host range of the fungus *Colletotrichum lagenarium* fruits of the following species were inoculated : *Cucumis sativus*, *Curcurbita maschata*, *Lagenaria vulgaris*, *Cucumis melo* var. *utilissimus*, *Momordica charantia*, *Cucurbita pepo*, *Citrullus vulgaris* and *Trichosanthes dioica*. The fruits were sprayed with spore suspension and covered with bell jars. Only *Lagenaria vulgaris* and *Cucumis melo* var. *utilissimus* became infected, almost all the fruits in these species being damaged.

8. Chilli

Leaf and Pod spot.—A new disease of chilli due to a species of *Alternaria* was described by Dr. Mitra and Mr. K. M. Dutt. The fungus produces spots of greyish or greyish-brown colour, oval, roundish or irregular in appearance with concentric rings, on leaves, twigs and fruits of chilli plants in the vegetable gardens in the neighbourhood of Delhi. Inoculations made on chilli fruits proved the pathogenicity of the fungus. The disease seems to be widespread.

* The complete list of varieties tested was as follows :—Co. 213, 214, 223, 244, 281, 285, 290, 299, 312, 313, 331, 352, 354, 360, 362, 402, 411, 412, 413, 417, 419, 421.

9. Cinchona

Three main diseases of cinchona were observed which were doing a good deal of damage to the plantations at Munsong. Firstly, the disease that causes splitting of the bark, secondly, the wilting disease of seedlings in the nursery and thirdly, the leaf spot disease. A species of *Rhizoctonia* was isolated from the plant showing the splitting disease, and a species of *Fusarium* from wilted plants from three different localities. Single spore isolations were made of different *Fusarium* species for morphological studies in different media. A species of *Gloeosporium* was isolated from a leaf disease which shows as dark brown circular spots on the leaves.

10. Mango

Specimens of mango twigs received from Bengal were attacked by *Dimerosporium mangiferum* (Cke and Broome.) Sacc. The interior of the wood was ash grey and black mycelium was present. On incubation in a moist chamber numerous dark pycnidia appeared on the tissue. They had dark bicelled striate spores like those of *Diplodia natalensis*.

11. Fruits in Delhi Market

A study of seasonal effects on development of rotting in fruits and vegetables brought for sale to the markets of Delhi was commenced in November, 1937 and since then fortnightly visits have been paid to the markets.

Apples, which come mainly from the North-West Frontier Province and Kashmir, showed rotting of five to twenty-five per cent of the fruits. In November, most of the damage was due to *Aspergillus* and *Penicillium* but after December, the cause appeared to be almost exclusively *Penicillium*.

Orange, from Nagpur, showed marked variation in the amount of rotting (from three to thirty per cent) the chief rotting organism being *Pencillium digitatum*. From February to May damage was less and appeared to be due partly to bacteria.

Pears were frequently badly damaged by species of *Aspergillus* which appeared to attack only fruits with slightly damaged skins.

Mangoes suffered from rots apparently due to a number of fungi but the predominant fungus was a species of *Dothiorella*. In the laboratory this fungus produced pycnidia in acid media. They are globose, aggregated on stroma, and measure 200—300 μ. The spores are hyaline and generally oval and measure $15{\cdot}2 \times 6{\cdot}5$ μ.

IV. THE GENUS *FUSARIUM*

Certain papers which have appeared recently both in India and abroad have made reference to work done at this Institute on the fungus which causes wilt of pigeon-pea (*Cajanus cajan*=*C. indicus*). This fungus was originally described by E. J. Butler ([1]) as *Fusarium udum*, though it was given this name without prejudice to the question whether or not it had been previously described under a different specific name. In 1926 Butler ([2]) considered the status of this species and he came to the conclusion that the fungus causing wilt of pigeon-pea is indistinguishable from that which causes wilt of Til

(*Sesamum indicum*) and cotton (*Gossypium herbaceum*) and should be considered as *Fusarium vasinfectum*. Even *Fusarium cubense*, he suggested, might not be distinguishable from *F. vasinfectum*.

M. Mitra (3), working at this Institute, published a paper in 1934 in which he concluded that the wilt disease of sann-hemp is due to *F. vasinfectum*. According to Mitra's experiments in which diseased material from the previous year's infected plants was used as inoculum, it appeared that the sann-hemp organism could infect pigeon-pea quite readily and *vice-versa*, but that neither of these strains could infect cotton or *Sesamum*. Uppal and Kulkarni (5) failed to substantiate the findings of Mitra. *F. vasinfectum* from sann-hemp could not infect pigeon-pea or *vice-versa*, though they could infect their own hosts heavily. The organisms used were single spore isolations from wilted sann-hemp and pigeon-pea plants supplied by Mitra from Pusa. The authors raised an objection to the method used by Mitra of inoculating with wilted material of sann-hemp or pigeon-pea of the previous year.

Wollenweber (6) has now published results of a study of a fungus which he isolated from wilted pigeon-pea sent by Butler in 1905 from Pusa. This fungus, which he designates F. *lateritium* var. *uncinatum* causes not a true wilt of pigeon-pea, but a foot-rot. He attributes some of the contradictory results reported to a failure to appreciate fully the difference between foot-rot and wilt.

In order to attempt to straighten out what is admittedly a muddle Mr. Mehta and Dr. Padwick are undertaking an examination of species of *Fusarium* associated with pigeon-pea (*Cajanus cajan*), sann-hemp (*Crotalaria juncea*), cotton (*Gossypium* spp.), gram (*Cicer arietinum*) and other plants. While it is too early to draw any conclusions it is interesting to record that from wilted pigeon-peas alone, several distinct species of *Fusarium* have been isolated, and one which seems to be different from Butler's *Fusarium udum* produces a severe wilting without any sign of foot-rot. The identity of this fungus is being determined.

The importance of clarifying the position is of economic significance. It is not just an academic controversy that has to be settled. A great deal of work has been done at this Institute (McRae and Shaw) in the selection of varieties of pigeon-pea resistant to wilt. Similarly, elsewhere, selection of cotton for resistance to wilt has been going on. If it cannot even be agreed as to whether or not the strain of *Fusarium* which attacks pigeon-pea is the one which attacks sann-hemp, it is clear enough that the basis for selecting resistant varieties within a species is not sound. Consequently it is at first a fundamental mycological problem to settle the question as to which organisms are responsible for wilts in the various crops.

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(1) Butler, E. J. The wilt disease of pigeon pea and the parasitism of *Neocosmospora vasinfecta* Smith. *Mem. Dept. Agric. Bot. Ser. Ind.* **2** : 1-64, 1910.

(2) Butler, E. J. The wilt disease of cotton and *Sesamum* in India. *Agric. J. Ind.* **21** : 268-273, 1926.

(3) Mitra, M. Wilt disease of *Cerotalaria juncea* Zinn. (Sann-hemp). *Ind. J. Agric. Sci.* **4** : 701-714, 1934.

(4) Narasimhan, R. A preliminary note on a *Fusarium* parasitic on Bengal Gram (*Cicer arietinum*). *Year Bk. Madras Dept. Agric.* 1928 : 5-11, 1929.

(5) Uppal, B. N. and Kulkarni, N. T. Studies in *Fusarium* wilt of sann-hemp. I The physiology and biology of *Fusarium vasinfectum* Atk. *Ind. J. Agric. Sci.* **7** : 413-442, 1937.

(6) Wollenweber, H. W. Fusariosen des Katjangs, *Cajanus indicus*. *Arb. biol. Reichs. Land—u .Forst.* **22** : 339-347, 1938.

The genus *Fusarium* is a notoriously difficult one to study and it is best tackled by taking a wide view. With this as the object the distribution of the genus *Fusarium* itself is being undertaken, and a number of interesting species are being examined. The *Fusarium* associated with gram wilt which has been studied by Mr. N. Prasad appears to be closely related to *F. orthoceras*. It is distinctly different from the organism found by Narasimhan (4) to cause wilt in Madras.

Two other species of *Fusarium* have attracted attention. A *Fusarium* has been found regularly associated with the decaying roots of oranges from places as widely separated as Sikkim, Bihar and Hyderabad (Deccan). The other interesting *Fusarium* is one which has been isolated from wilted *cinchona* plants at Munsong. Again a single species was regularly isolated from the vascular tissue. Both these species of *Fusarium* are being identified.

V. MISCELLANEOUS

A total number of fifty-five specimens were supplied from the herbarium to workers in various parts of India and abroad.

Aeroscopic slides were exposed for Dr. K. C. Mehta of Agra College, and in addition wheat and barley crops were examined for the earliest dates of appearance of rust and the results were communicated to him.

Fungi, mostly common moulds, were identified for a number of workers.

During the year 244 specimens were added to the harbarium and the living culture collection was increased in number from 104 to 200 cultures.

Help in a number of technical problems was given by the Imperial Mycologist to the Imperial Council of Agricultural Research.

VI. SYSTEMATIC WORK

Exsiccatae received from several herbaria abroad have been examined by Dr. Mundkur, whose former conclusion that more than one species of smut affects the genus *Saccharum* has been strengthened.

Collection of smuts in the Herbarium Crypt. Ind. Orient. are being examined in order to check the determinations. A species of *Tilletia* collected on *bajra* (*Pennisetum typhoides* Stapf.) seems to be an undescribed species.

A rust on *Acacia modesta* Wall. was found to be an undescribed species and was named *Ravenelia Taslimii*.

VII. PROGRAMME OF WORK FOR 1938-39

1. Smuts diseases of cereals with special reference to varietal resistance. Taxonomy of smuts.

2. Late blight of potatoes—preliminary work for testing for resistance.

3. Fruit and vegetable diseases—completion of investigation of seasonal influence in Delhi market.

4. Diseases due to *Fusarium*. Identification of causal organisms.

5. Wilt of gram. Studies on etiology of disease and on varietal resistance.

6. Soil conditions in relation to disease development.

7. Leaf-curl of tobacco. Continuation of study of transmission.

8. Mosaic and other diseases of sugarcane, with special reference to varietal resistance.

9. Collection and identification of specimens, identification of fungi received in culture, development of herbarium and culture collection.

VIII. PUBLICATIONS

1. Dutt, K. M. . . *Alternaria* sp. on chilli in India. *Curr Sci.* **6** : 97-98.

2. Lal, T. B. . . *Uromyces rumicis* (Schum.) Winter, a new record for India. *Ind. J. Agric. Sci.* **7** : 933-934, 1937

3. Mehta, P. R. . . A fruit-rot of apple caused by a species of *Rhizopus*. *Curr. Sci.* **6** : 58-59.

4. Mehta, P. R. and Chakraverti, S. C. . A new disease of *Eleusine coracana* Gaertn. *Ind. J. Agric. Sci.* **7** : 793-796, 1937.

5. Mitra, M. and Mehta, P. R. . . . Some leaf diseases of *Hevea brasiliensis* new to India. *Ind. J. Agric. Sci.* **8** : 185-188, 1938.

6. Mundkur, B. B.. . Phytopathology and Mycology in 1937. *Ann. Rev. Biochem. Allied Res. Ind.* **8** : 123-133, 1938.

7. ————————. . Fungi of India, Supplement I. *ICAR. Sci. Monogr.* **12** : 1938.

8. ————————. . Host Range and Identity of smut causing root-galls in the genus Brassica *Phytopathology* **28** : 134-142, 1938.

9. ———————— and Prasad, N. On a new Ravenelia from India *Mycologia* **30** (in press).

10. Prasad, H. H. . . A soft rot of pear caused by a species of *Aspergillus*. *Ind. J. Agric. Sci.* (in press).

11. Subramaniam, L. S. and Chona, B. L. Note on *Cephalosporium sacchari* Butl. (Causal organism for sugarcane wilt). *Ind. J. Agric. Sci.* **8** : 189-190, 1938.

The following abstract was contributed to the Indian Science Congress, Calcutta sessions, 1938.

Mitra, M. . . . Effect of the locality and the time of sowing on the incidence of "spot blotch" disease of barley.

REPORT OF THE IMPERIAL ENTOMOLOGIST

(HEM SINGH PRUTHI)

I. SPECIAL INVESTIGATIONS

1. ECOLOGY OF SPOTTED BOLLWORMS OF COTTON AND THEIR IMPORTANT PARASITES.

The fecundity and development of *Earias fabia* stoll. and its parasites, *Microbracon lefroyi* D. & G., and *Melcha nursei* Cam., were studied at constant temperatures of 16°C. and 20°C. and saturation deficiencies of 0, 3 and 9 mm. Important conclusions so far arrived at are summarised below :—

(i) *Earias fabia*.—Other factors being the same, high temperature during preimaginal period increased the fecundity, while low temperature decreased it. For example, moths kept at 16°C. after passing the preimaginal life at 16°C., 20°C. and 26-35°C. laid on the average 29, 37 and 75 eggs respectively per female.

Like temperature, humidity has a marked influence on fecundity. Moths kept at 16°C. laid 6 and 29 eggs per female at saturation deficiencies of 9 and 3 mm. respectively, and those kept at 20°C. laid 9, 27, 47 and 94 eggs per female at saturation deficiencies of 14, 9, 3 and 0 mm. respectively. Thus moist conditions within certain limits increase the reproductive power while dry conditions retard it.

The rate of development is also influenced by temperature and humidity. The incubation period was 11-12 days at 16°C. and about 7 days at 20°C., the larval period was about 35 days at 16°C. and 20 days at 20°C. and the pupal period varied between 32-33 days at 16°C. and 17-18 days at 20°C. It is interesting to note that temperature being the same, the rate of development is quickest at a saturation deficiency of 3 mm. The threshold of development lies between 10°C. and 13°C.

(ii) *Microbracon lefroyi*.—This parasite develops much more quickly than the host. As a rule the female lays more than one egg on a single host larva. The average number of host larvae killed by a female parasite was 5-7. In the following table the pre-oviposition period, the duration of various stages and the maximum number of eggs laid by a female at various temperatures and 100 per cent R. H. are given :—

Temp.	Pre-oviposition period (days)	Maximum number of eggs laid by a female	Incubation period (days)	Larval duration (days)	Pupal duration (days)	Longevity of the female parasite (days)
16°C. . . .	8·2	39	2·68	6·1	18·6	30·3
20°C. . . .	4·7	32	1·63	4·9	12·2	13·0
25°C. . . .	4·0	58	1·31	2·6	6·9	15·3

With regard to moisture the optimum condition for the development of the parasite was found to be a saturation deficiency of 0 mm. (saturated atmosphere) as against one of 3 mm. for the host.

(iii) *Melcha nursei*.—The rate of development of this parasite is comparatively slower than that of *Microbracon lefroyi* but still much faster than that of the host. It prefers to oviposit on prepupæ, *i.e.*, soon after the bollworm hosts have completed their cocoons. At 16°C., the number of eggs laid varied from 6 to 23 but the total number of pupae paralysed was seldom less than 56 per female, the maximum being 150. A female which laid 6 eggs, paralysed as many as 104 host pupae. The following table gives the duration of various stages at 100 per cent R. H. three temperatures tried :—

Temp.	Pre-oviposition period (days)	Incubation period (days)	Larval period (days)	Pupal period (days)	Longevity of the female parasite (days)
16°C.	2—3	2·7	8—10	26—30	39—67
20°C.	2	2·2	6—7	16—18	23—26
24°C.	1	1·2—1·9	5—6	11—12	15—16

2. Insect Vectors of Tobacco leaf-curl in Northern India.

In our previous investigations on tobacco leaf-curl it was shown on the basis of some preliminary experiments that sann-hemp is an alternate host of leaf-curl virus and that the white-fly *Bemisia gossypiperda* M. & L. could transmit the disease from sann-hemp to tobacco plants. Since then a large number of transmission experiments have been performed to confirm previous conclusions and to ascertain if the white-fly could also transmit the disease from tobacco back to healthy sann-hemp, and from tobacco to tobacco and sann-hemp to sann-hemp. Moreover, during the course of the work it was observed that the common weed *Ageratum conyzoides* also suffers at Pusa from a leaf-curl disease and is a host of the white-fly. This weed has also been experimented with to determine if this plant like sann-hemp is an alternate host of tobacco leaf-curl virus, and if so, the role of the white-fly in the transmission of the virus from this weed to tobacco and sann-hemp and *vice versa*. About fifty large series of experiments on the lines indicated above have been performed at different times of the year on tobacco and other host plants of different ages to determine the season when the white-fly is most infectious and the age of various hosts when they most readily get infected and develop the disease. The following conclusions could be drawn from the work :—

The white-fly is an important vector of tobacco leaf-curl viruses of all the five types.

Sann-hemp is definitely an important alternate host of the tobacco leaf-curl viruses A and X, the two viruses causing different symptoms in sann-hemp, giving rise to two types of disease, which have been designated as S. V. 1 and S. V. 2. The white-fly can easily transmit both types of disease

from sann-hemp to tobacco. As the sann-hemp and tobacco seasons slightly overlap in North Bihar, it is very likely that sann-hemp is an important source of infection for tobacco.

Though the white-fly can transmit leaf-curl from tobacco back to sann-hemp, it does not, however, seem to be a very efficient vector in this respect. Only during the month of July some positive transmissions were obtained, using diseased tobacco of last year as the source of infection. In nature, sann-hemp seems to get the infection sometime in July. In North Bihar leaf-curl does not appear in tobacco before about the middle of September, therefore tobacco does not seem to serve as a source of infection for the disease in sann-hemp.

The weed *Ageratum conyzoides* is also an important alternate host of tobacco leaf-curl, especially of D type. The white-fly is capable of easily transmitting the disease from this host to tobacco. Sometimes 60 per cent positive transmissions were obtained. The white-fly can also easily transmit the disease from tobacco to the weed, sometimes 100 per cent positive transmissions being obtained. *A. conyzoides* is a perennial weed in North Bihar and it is therefore evident that it is an important source of infection for the leaf-curl of D type of tobacco and can easily get the infection back from that crop. The white-fly is capable also of easily transmitting the disease from sann-hemp to *A. conyzoides*, though it cannot transmit the disease back to sann-hemp so easily. Thus *A. conyzoides* is very highly susceptible to getting the disease from both tobacco and sann-hemp, sometimes cent per cent positive transmissions being obtained.

Regarding the role of the white-fly as a vector of leaf-curl from diseased to healthy tobacco, the results of two years' experiments show that the white-fly could transmit the disease only in a few cases. Therefore it appears that in nature the diseased tobacco is not an important source of infection for healthy tobacco, and that the alternate hosts referred to above, *viz.*, sann-hemp and *A. conyzoides* seem to play a much more important part in this connection. These two hosts harbour leaf-curl viruses, A, D and X types; the alternate hosts, if any, for B and C types remain yet to be discovered.

Experiments show that tobacco is most susceptible to getting the infection if it is about 8 weeks old and if the infection takes place in autumn (from the middle of September up to the middle of November) or in February. Experiments performed with about 8 weeks old tobacco between the middle of November and the end of December or with older tobacco during the autumn gave comparatively a low percentage of positive transmissions. The behaviour in the case of sann-hemp is similar. It is most susceptible during the months of July and August, when it is about 2-3 months old. Thus the disease is very much influenced by the age of the host plant. Regarding the autumn and spring seasons being more suitable than winter for the infection of tobacco, it is likely that the air temperature and humidity during these seasons are conducive to the proper development of the disease symptoms.

The incubation period of the disease inside the infected plant seems to be connected with the question of the accentuation or supression of the symptoms of the disease referred to above. It was noticed that the age of the infected tobacco remaining the same, the incubation period was generally minimum if the infections were done during September and October or in

February when the air temperature starts rising at Pusa. The period was generally the maximum if the infections were done during December. Apart from air temperature, it is quite likely that the white-fly is most viruliferous at these times of the year, which again may be due to several environmental factors including temperature and humidity.

We have not performed exact experiments to determine the length of time necessary for the white-fly to feed on the diseased host for successfully transmitting the disease to healthy host, but the general transmission experiments show that the white-fly can transmit the virus after five to six hours' feeding, shorter periods having not been tested.

The minimum number of white-flies tested and found successful for the transmission of the disease from sann-hemp to tobacco was 5; for the transmission from tobacco to sann-hemp and from sann-hemp to sann-hemp the number was 2. Fewer numbers in these cases were not tested. In the case of *Ageratum* to tobacco one white-fly was found to be able to transmit the disease.

Besides sann-hemp and *Ageratum*, we have observed the white-fly freely breeding on a number of other plant hosts, some of which (cucurbits, hollyhock, *Zinnia*, *Scoparia*, *Sida* sp., etc.) show leaf-curl, which may be closely allied to if not identical with tobacco leaf-curl. Therefore it appears that unlike most viruses the tobacco leaf-curl viruses, may have a big host range and thus resemble those of aster yellows, tomato spotted wilt, tobacco ring spot, etc. If this is true, the problem of the control of the disease by the eradication of alternate host plants becomes very difficult and the chances of success by keeping the white-fly under check by direct control methods appear to be greater.

3. Pests of fruits and vegetables

The survey of Codling moth started in April, 1937 was completed during the year under report. The main conclusions obtained from the work are as follows:—

The Codling moth is widely distributed in Baluchistan and constitutes a major pest in that province. It attacks apple, pear and quince fruits. During the summer of 1937, 50 to 85 per cent of apple fruits were found damaged by this pest. The larvae of *Spilonota ocellana* Schiff. damage chiefly the leaf and flower buds of apple and though sometimes they nibble the surface of apple fruits and cause shallow injuries, they do not bore into the fruit as is done by the Codling moth larvae. The larvae of another moth, *viz.*, *Euzophera punicella* Moore, were sometimes found in large numbers inside the fruits along with the Codling moth larvae, but they do not seem to be pests of sound fruits and therefore are of secondary importance only. The larvae of *Euzophera* and Codling moth are apparently very similar, and therefore liable to be confused with one another. It appears probable that Codling moth was and is being introduced into India by being carried inside infested apples imported from Afghanistan.

The incidence and bionomics of the fruit-fly (*Chaetodacus ferrugineus* Fab.), a serious pest of fruits in the North-West Frontier Province, was further investigated. This pest is active in the Peshawar District from July up to the end of September and attacks 50 to 70 per cent of peach (late variety) and pear. In Kohat District, 50 to 80 per cent of loquot, apricot, guava

and fig crops are attacked in succession from April to November, while peach, pear and persimom are attacked to the same extent in Parachinar from mid-August to October. The life-history of this pest was studied in detail at Kohat during August and September. The female lays eggs inside the fruit by puncturing it with its ovipositor. Both unripe and slightly ripe fruits are thus punctured, the number of punctures varying from 1 to 15 according to the size and nature of the fruit. In most fruits the first signs of attack take the form of an oozing fluid at the site of puncture. The maggots, which hatch in 24 to 48 hours, feed on the fruit pulp which consequently rots. The full-grown maggots have the habit of hopping out of the fruit even when it is on the tree, and the pupation takes place in the soil or in the dried up fallen fruits. At Kohat under field conditions in September the larval stage lasted 7-8 days, the pupal 6-7 days; the newly emerged flies lived 6-10 days, but if starved, only 2-3 days.

Experiments on a large scale were carried out at Kohat to test the effect of various baits and poison sprays on the fruit-fly. The results showed that the citronella bait attracted the largest number of flies but its value was negatived by the fact that its attraction was confined exclusively to male flies. Of the remainder, clensel and pollard baits were found almost equally useful, the latter being slightly cheaper and its ingredients are also more easily available in villages. Sodium fluosilicate bait-spray proved ineffective. A cheap trap was devised, costing about two and a half annas.

Observations were made on the biology of the apricot chalcid (*Eurytoma samsonowi* Vasilj.), an important pest of apricots in the N. W. F. Province. The pest is found in the grub stage inside the kernels of fruits from May up to the middle of the following February. The infested fruit readily falls off the trees. Of the grubs in 460 infested fruits collected, about 40 per cent pupated and emerged as adults during the first three weeks of March, 43 per cent failed to pupate and died and the remaining 17 per cent continued to remain in the grub stage and would probably pupate next year. The grubs pupate inside the seeds and the adult emerges by making a hole in the testa and then boring a fine hole in the woody wall of the fruit. In the spring of 1938, the pest appeared in apricot orchards at Haripur about the 20th March on the *Kori* variety, which is the earliest to ripen. This variety was severely attacked in May when 60 to 80 per cent of the fruits in some orchards were infested. It seems that the eggs of the chalcid are laid in young unripe fruits, the punctures of oviposition healing up almost immediately. A study of the external morphology of the grub and pupa was also made.

The *ak* grasshopper, *Poecilocerus pictus*, hitherto regarded as harmless, so far as cultivated crops are concerned, has now become a pest of some importance. In addition to feeding on *ak* (*Calotropis* sp.) it has been observed to attack leaves and fruits of brinjal, tomato and castor, and leaves and seedlings of gourds, etc., at Delhi. A close study of the life-history and habits of this insect has, therefore, been made. Eggs are usually laid in masses of about 100 each in the soil, during June to August. They do not hatch, till the next spring, except a very small proportion, which hatch after an incubation period of 7-8 weeks, and pass the winter in the nymphal stage. The number of nymphal moults, which varies with sexes as well as with the season of hatching, *viz.*, before and after winter, the duration of various stadia in the life-history under different temperatures, etc., were studied.

The hoppers that hatch out in spring undergo 5-7 moults and take 7-9 weeks to become adults, each stadium taking 1-2 weeks. The hoppers which overwinter undergo one or two extra moults before becoming adults in the following spring. It seems that development below 24°C. is not possible while between 32° and 35°C. it is fairly rapid. A test of the range of food-plants showed that this insect could feed well on leaves of brinjal, tomato, cow-pea, soy-bean, castor, cabbage, radish, gourd, *bhindi* (*Hibiscus esculentus*), oleander and maize ; to some extent, on cotton and *Dolichos lablab* ; and very little on *Cajanus cajan*, tobacco and *bajra*. On the whole *ak* seems to be the most favourite food-plant, and it is only when most of it in the field has been attacked and eaten away by about the middle of June that the insect turns its attention to cultivated crops.

Work on the life-history and morphology of the Amarantus borer, *Lixus truncatulus* F., and its natural enemies, which was interrupted due to the move from Pusa, was completed in New Delhi. This insect occurs as a minor pest of Amarantus throughout the plains of India. In summer one cycle is completed in about two months ; in winter all stages of the weevil were seen undergoing slow development. Of the parasites, which were recorded from this host for the first time from India, *Pareuderus torymoides* Ferr., was the most important, parasitising 31 per cent of the eggs at Pusa. There is a marked sexual dimorphism in the larval parasite *Dinarmus sauteri* Masi, the male of which had not been described so far.

4. Pests of stored grain

The study of some important pests of grain begun last year was continued. The life-history of the rice moth (*Corcyra cephalonica* Stn.) was worked out on wheat. Oviposition usually started in April. Eggs which were laid singly on grains or any rough surface, hatched in 3-6 days during April, May and September, and the number laid by a single female varied between 100 and 200. The larvæ moulted 4-8 times during a period of 25-40 days. Sometimes (in September and October) the larval period was even 96 days when there were as many as 12 moults. The larvæ hibernated in winter and the adults emerged in spring. The pupal stage lasted 9-12 days and the cocoons formed a sort of webbing by adhering grains of wheat and rice to them. The adults usually did not feed and lived for one to two weeks only.

The study of the longevity and fecundity of the rice weevil (*Calandra oryzae*) under different conditions of temperature and relative humidity was continued. Weevils were kept at 20°C. but under four relative humidities, *viz.*, 36 per cent, 56 per cent, 68 per cent and 87 per cent, corresponding to saturation deficiencies of 11-12, 8-9, 5-6 and 2-3 millimeters respectively. The first two humidities seem to be very unfavourable, especially the first under which the weevils died cent per cent in 7-12 days. The third (68 per cent) was more suitable. At the fourth humidity (87 per cent), the total period of development from egg to adult was found to be 6-7 weeks, of which the larval period occupied 4-5 weeks and the pupal period 11-16 days. At 16°C. and relative humidity 90-92 per cent development was very slow but not arrested while at 13°C. and with the humidity unchanged, no eggs were laid. Thus, of the various humidities tried so far at a temperature of 20°C., a relative humidity of 87 per cent has proved to be the most favourable for the development of the weevil.

Experiments were started to test the effect of various repellents—sodium fluosilicate, lime, chalk, boric acid and coke ash, etc.—in keeping off the weevil attack on wheat. The final observations will be taken during and after the monsoon. The difficulty of keeping the weevils alive in the laboratory during the summer was again felt this year and the work was considerably dislocated.

5. Immature stages of Indian Insects

The study of immature stages of insects, whether pests or otherwise, was continued both in the field and the Insectary. As a result of this, much useful information regarding the occurrence, food habits, host relationships, seasonal distribution, natural enemies, etc., of a large number of insects was collected. Illustrations of immature stages and the modes of their injury were prepared and several new colour plates were finished. There is a great demand for colour plates of crop-pests from provincial Departments of Agriculture and various educational institutions.

During the year under report about 45 species of insects were successfully reared. Our greatest difficulty in rearing is the high temperature which usually prevails in the Insectary during summer, in spite of all arrangements of curtains and *khas tattis*. But for this several more interesting insects would have been reared.

Incidentally the work on immature insects also gives rise to problems of their proper preservation and an opportunity for testing the suitability of various methods and fluids under the hot and dry conditions prevailing for about half the year in Delhi.

6. Parasites and Predators

A taxonomic study of some important groups of parasitic hymenoptera, *viz.*, Chalcidoidea, Ichneumonidæ and Braconidæ, was started, and the parasites associated with major pests of important crops, *e.g.*, sugarcane, cotton, etc., were under study.

A new species of the Eulophid genus *Azotus*, found parasitising the white-fly of sugarcane, *Aleurolobus barodensis* Mask. at Karnal and Delhi, was described as *A. delhiensis* Lal. This species also constitutes the first record for the genus in India.

Seven new species of *Pachyneuron* (Pteromalidæ), another genus reported for the first time from India, were under study. These were bred from *Leucopis* spp., *Syrphus* sp., aphids, etc.

A revision of the Chalcidoid genus *Bruchobius*, four species of which have been reported from India so far, was made. The study showed the need for a new sub-family to receive this and two other allied genera, *Oedaule* Waterston and *Sphaerakis* Masi.

A general systematic revision of the Chalcidoid family Eucharidæ was also carried out.

Parasites of the Braconid genus *Microbracon*, reared from the spotted bollworms of cotton, were under examination first, to determine their exact identity and secondly, to find out if the species *M. lefroyi* D. & G., is the same as *M. greeni* Ashm., which is a parasite of the larva of *Eublemma amabilis*, a notorious predator of the lac insect.

The bionomics of the Chamaemyid fly, *Leucopis griseola* Fall, predaceous, in the larval stage, on the nymphs of *Aphis gossypii* Glover, was studied in detail. In the laboratory, the eggs of the predator, which were laid on the undersurface of cotton leaves, hatched in 4-7 days, the larval period was 16-21 days and the pupal period 29-49 days during November-January. A single larva devoured 70-100 aphid nymphs. Newly emerged flies could be kept alive in captivity for 6-8 weeks. The fly was also found attacking several other aphids, *e.g.*, *Macrosiphum granarium* Kirby, *Myzus persicae* Sulz., and some other undetermined species found on hollyhock, mustard, spinach, etc.

7. Insecticides

The efficacy of some insecticides was tested under different conditions against certain pests and the results so far obtained are sumarised below :—

Lead arsenate sprays (2 lb. to 100 gallons of water), sodium fluosilicate baits (sodium fluosilicate 1 part, bran 50 parts, *gur* 2 parts by weight) or sodium fluosilicate and lime dusts (1 : 4) proved unsuccessful against the hoppers and adults of *Poecilocerus pictus* on brinjal plants. Sodium arsenite, a soluble poison (2 lb. per 100 gallons of water) sprayed on the plants killed 33 per cent of the hoppers on the day of application and the remainder died within the next three days.

A poison bait containing sodium fluosilicate proved highly effective against crickets (*Gryllus domesticus*) damaging artificial silk in a textile mill at Amritsar.

To protect against white ants, sugarcane setts, immediately before planting, were immersed in the following solutions for 1/2 to 1 minute and dried in shade :—

(i) 5 per cent solution of lead arsenate in cold water.

(ii) 5 per cent solution of sodium fluosilicate.

(iii) 2 per cent solution of Paris green mixed with 4 per cent solution of lime.

(iv) Coal tar (the ends of the setts were smeared).

It was found that setts treated with lead arsenate and Paris green remained free from termite attack, whereas those treated with sodium fluosilicate began to show signs of attack after one month. Setts treated with coal tar as well as those kept as control were found damaged after three weeks.

Young cucurbit crops attacked by the pumpkin beetle, *Aulacophora foveicollis* (Lucas), were dusted with Paris green mixed with wood ash (1 : 80 parts by weight). Dusting 2 or 3 times at an interval of a week or so with this mixture proved very effective.

The efficacy of thallium sulphate as a poison in anti-ant baits was tested against *Camponotus compressus* Fab., *Monomorium* spp., and a few other species of ants. It was found that the bait when freshly made attracted large numbers of sweet-loving ants such as *Camponotus* and *Monomorium* spp., but its attractiveness decreased when stale.

II. OBSERVATIONS ON OTHER INSECTS

In addition to the intensive investigations on certain insects and problems described above, a large number of observations were taken in the field on a variety of insects and the information so gathered was, in many cases, checked during the rearings of the immature stages in the laboratory. The more important of these observations are given below :—

1. *A.—General*—A survey of aphids infesting wild and cultivated plants in Delhi revealed a large number of interesting species. *Aphis gossyppii* Glov. was observed breeding extensively on cotton during December, January and February, and *A. maidis* Fitch. on barley, wheat, *juar* and maize. *Myzus persicae* (Sulz.) was noted on a large variety of plants, *viz.*, radish, cauliflower, brinjal, carrot, potato, hollyhock, sugarbeet, *Convolvulus* sp., *Malva sylvestris*, *Medicago lupulina* and *Phlox drummondi*.

A collection of ants was made from different places in Delhi and Karnal. The harvesting ant, *Holcomyrmex scabriceps* Mayr., and the carpenter ant, *Camponotus compressus* Fabr., appeared to be the commonest species and of considerable economic importance. Among smaller ants, *Acantholepis frauenfeldi* Mayr., and a species of *Monomorium* were fairly frequently met with in fields and on foot-paths and a species of *Crematogaster* on *Acacia* trees. *Myrmecocystus setipes* Forel, another fairly common species, was found to be the most powerful and the fastest moving among the ants collected. A very virulent species, though exceedingly scarce, was *Sima rufonigra* (Jerdon).

B.—The following insects were noticed in pest form at Delhi and other places named :—

Agrotis flammatra Schiff., larvae on leaves of cauliflower and *Eruca sativa*.

Ocinara varians Walk., larvae on leaves of *Ficus retusa*.

Phyllotreta cruciferae Goez., on cruciferous crops at Agra, Delhi, Karnal and Jullunder.

Amsacta moorei Swinh., caterpillars appeared in large numbers on sann-hemp and in smaller numbers on several low-growing crops such as cow-pea, soy-bean, maize, *Basella rubra*, *Cucumis pepo*, *Lagenaria vulgaris*, etc.

Euzophera perticella Rag., caterpillars seriously damaging brinjal plants.

Euproctis lunata Walk., on castor.

Earias spp., larvae feeding on cotton buds and bolls, *bhindi*, etc.

Emmalocera depressella Swinh., caterpillars boring at roots of sugarcan plants.

Phytomyza atricornis Meig., mining leaves of pea, mustard, radish and turnip and to a lesser extent of cabbage, cauliflower, and linseed besides those of several economically unimportant plants.

Agromyza obtusa Mall., on pods of *Cajanus cajan*.

Dacus ciliatus Loew., and *Chaetodacus cucurbitae* (Coq.), infesting fruits of various cucurbits.

Pyrilla purpusilla Walk., on sugarcane and *juar*.

Empoasca devastans Dist., on *Hibiscus esculentus*.

Aphis maidis Fitch, on barley.

Myzus persicae Sulz., on potato.

Macrosiphum sonchi Linn., on safflower.

Gryllodes sigillatus Walk., and *Gryllus domesticus* L., causing annoyance and contamination of food in houses.

Cyrtopeltis tenuis Reut., on tobacco and wild cucurbits.

Aulacophora foveicollis (Lucas), attacking various cucurbits.

Termites damaging sugarcane and several other cultivated crops.

C.—The following insects which are usually pests in other localities, were noted in Delhi and neighbouring areas in rather small numbers :—

Cirphis unipuncta Haw., larvae on berseem, barley and linseed at Karnal.

Plusia nigrisigna Walk., larvae feeding on gram, knol kohl, carrot and cauliflower, etc.

Leucinodes orbonalis Guen., larvae boring flower buds, fruits and shoots of brinjal.

Eublemma olivacea Walk., larvae rolling leaves of the brinjal plant.

Achaea janata Linn., larvae on castor leaves.

Dichocrocis punctiferalis Gn., larvae boring castor capsules.

Utetheisa pulchella Linn., larvae on leaves of *Heliotropium eichwaldi* Stud., and sann-hemp.

Scirpophaga nivella Fabr., on sugarcane.

Diatraea sticticraspis Hmp. on sugarcane.

Chilo zonellus Swinh., on *juar* and maize.

Marasmia trapezalis Guen., rolling and feeding on leaves of *juar*.

Diaphorina citri Kuw., on *Citrus* spp.

Epilachna dodecastigma Muls., feeding on leaves of cucurbitaecous plants.

Euxoa segetum Schiff., larvae cutting leaf twigs of potato.

Etiella zinckenella Treits., larvae boring pods of *Pisum sativum*.

Hellula undalis Fabr., larvae on turnip leaves.

Prodenia litura Fabr., on castor.

Creatonotus gangis Linn.

Plutella maculipennis Curt.

Laphygma exigua Hubn.

Heliothis obsoleta Fabr., larvae on leaves flowers and pods of gram, leaves and flower buds of hollyhock, flowers of *Malva sylvestris*, leaves of cabbage, berseem and radish, leaves and pods of pea and *Cajanus cajan* and fruits of tomato.

Bemisia gossypiperda M. & L., on cotton and several other plants.

D.—The following important predators and parasites were noted at Delhi, either on wing or on hosts mentioned against them :—

Coccinella undecimpunctata Linn., predaceous mostly on aphids,

Coccinella septempunctata Linn., and *Chilomenes sexmaculata* Fabr., attacking aphids infesting potato, brinjal, carrot, berseem, sunflower and *Carthamus tinctorius*.

Actia monticolla Mall. (?) and *Dioctes* sp., parasitic on caterpillars of *Laphygma exigua*.

Henicospilus merdarius Gravenhorst, very common during January-March.

Rhogas testaceous Gravenhorst, *Elasmus* sp., *Actia aegyptia* Vill., *Disophrys* sp., parasitic on well developed larvae of *Earias* spp.

Brachymeria tachardiae (Cam.), on pupa of *Earias* spp., and of *Anomis flava*.

Systasis sp. on *Dasyneura lini* maggots.

Scymnus gracilis Motschulsky, *Scymnus nubilis* Muls. and *Thea bisoctonotata* Muls., predaceous on various aphids.

Homalotylus flaminius (Dalm.) parasitic on *Adonia variegata*, *Chilomenes* and other Coccinellids.

E.—The following other insects were also noted :—

The Sphegids, *Sceliphron madrasapatanum* (Fabr.) and *S. violaceum* (Dahlb.) at flight during morning hours and the latter building mud nests on branches of trees in September.

Apis dorsata Fabr., visiting flowers of berseem and *Carthamus oxycantha*.

Musca nebulo Fabr., *M. vicina* Macq., and *M. xanthomelas* Wied., breeding in manure heaps.

Anthia sexguttata Fabr., from a hole in *Acacia* tree.

Pandora sp., on various plants, *e.g. Terminalia* spp., cotton, etc.

Pseudococcus citri Risso on *Citrus*.

Anomalococcus indicus Green on *Acacia* stem.

III. INSECT COLLECTIONS

The rearrangement of our insect collection consequent on the transfer of the Institute to New Delhi has been completed now and most of the specimens have been cleaned and, where necessary, repaired. A large part of the collection was transferred from the old store boxes to glass-top drawers in cabinets and a further improvement in arrangement was the labelling of all cabinets with the names of the families and genera contained in their drawers. Attention was also given to the fairly large collection of specimens in spirit, mostly of the immature stages of insects, by sorting them out into their groups and attending to their preservatives.

The registration and cataloguing of named insects was continued and during the year about seventeen thousand more specimens were registered and cards of over two thousand species giving information about their food-plants and distribution were prepared, bringing the total, up to date, to about fifty-four thousand specimens and about five thousand species respectively.

The identification of the unnamed collection, which is always being augmented by the collections brought in daily from the field or received from various parts of the country, was proceeded with in the Section as well as outside

through the help of institutions and specialists. As a result of this, over two thousand named insects comprised in about 200 species were incorporated in our collection during the year under report. The institutions and specialists who rendered us assistance in the naming of our collection include :—

1. The Imperial Institute of Entomology, London.
2. The Forest Entomologist, Dehra Dun.
3. Mr. H. K. Munro, Division of Plant Industry, Union of South Africa.
4. Mr. S. Maulik, British Museum, London.
5. Bureau of Entomology, United States Department of Agriculture, Washington, D. C.

About a dozen species of Hymenoptera, 27 species of Coccinellidae, six species of moths and 17 species of Rhynchota were received as donations or in exchange from among others, the following institutions and individuals, whose generosity is gratefully acknowledged :—

(i) The Ministry of Agriculture, Egypt. (Braconidae.)
(ii) The Lac Research Institute, Ranchi. (Braconid and Chalcidoid parasites.)
(iii) Col. F. M. Bailey, Nepal. (Rhynchota.)
(iv) Mr. F. C. Camargo, Agronomical Institute, Brazil. (Coccinellidae.)
(v) Entomologist to Government, Punjab.
(vi) Entomologist to Government, Madras.

Numerous outside workers consulted the Pusa collection.

Named specimens from our collection were supplied to the following workers :—

1. Miss. R. Shah, Horticulturist, Nagpur. (Insect pests of Citrus.)
2. Dr. J. K. Dubey, Director of Agriculture, Bhopal. (Some insect pests of crops.)
3. Prof. J. J. Asana, Gujrat College, Ahmadabad. (Spotted boll-worms.)
4. Species of *Xylocopa* in our collection were loaned to the Director, Zoological Survey of India, Calcutta, for study.
5. Fresh specimens of the red cotton bug, *Dysdercus cingulatus* Fab., were supplied to Mr. Luiz O. T. Mendes of Brazil.
6. Living specimens of bedbugs (*Cimex rotundatus*) were supplied to Prof. Albrecht Hase, Berlin.

IV. ADVISORY

Identification of insects.—About 70 different species of insects were received from various correspondents from all over India and identified as far as possible.

Information about insect pests.—About 65 enquiries regarding the distribution, biology, literature and control of insect pests and parasites, received

from various parts of India and abroad were attended to, of which the more important ones are summarised below :—

Advice regarding the control of blood-sucking flies and mosquitoes was given to the Officer Commanding, Remount Depot, Saharanpur ; regarding bed bugs and cockroaches to the Civil Surgeon, Howrah ; regarding black ants to the Malariologist, B. N. Railway, Calcutta.

Measures for the control of the cotton jassid were suggested to Rai Bahadur D. H. Punwani, Hyderabad, Sind, and of the white-fly of sugarcane to the Secretary, Hindustan Sugar Mills Ltd., U. P.

Advice about the control of wasps in residential buildings was given to the Military Secretary to His Highness the Nawab of Bhopal.

Information on suitable hosts for the mass multiplication of *Trichogramma minutum* was supplied to the Forest Entomologist, Burma.

The Director of Agriculture, Sind, was advised in regard to a scheme for the control of the black-headed cricket in Sind.

Methods of controlling white-ants damaging buildings or crops were suggested to several correspondents, *e.g.*, the Chief Engineer, Kidderpore, Calcutta ; the Manager, National Iron Foundry, Agra ; the Agriculturist, Agricultural Research Station, Sakarand ; the Superintendent, Viceregal Gardens, New Delhi, etc.

A list of 78 Indian species of the genus *Monolepta* (Chrysomelidae) together with a list of the food-plants of *M. signata* was supplied to the Professor of Zoology and Entomology, Agricultural College, Cawnpore.

A list of important literature on Indian and other Coccinellidae was supplied to the Professor of Entomology, Agricultural College, Poona, and on the taxonomy of *Trogoderma khapra* to the Entomologist to Government, Punjab, Lyallpur.

The house cricket, *Gryllus domesticus* L., doing serious damage to artificial silk in a textile mill at Amritsar, was successfully controlled with poison baits and by destruction of its breeding places.

A consignment of beans attacked by Bruchid beetles, intercepted by the Ministry of Agriculture, Japan, was examined and reported upon.

Advice regarding the design of a fly trap was given to the Principal, Bihar Veterinary College, Patna.

Information about the natural enemies of cotton stainers in India was supplied to Dr. J. D. Tothill, Uganda.

Information regarding the saw-fly pests in India was sent to Herr Helmut, Verbinger, Berlin.

Flower and vegetable crops in some private gardens in New Delhi were sprayed and dusted for various insect pests and one bungalow was treated against white and black ants.

Anti-mosquito and fly campaigns were carried out throughout the year on the estate of the Institute, and these pests were appreciably kept down.

Bee-keeping.—About seventy enquiries from different parts of India were received and answered. These related to literature on bee-keeping, control of foul brood disease, the desirability of importing foreign bees, nectar-yielding forest trees, etc. Wax comb foundation sheets (prepared in the laboratory), zinc queen excluders, etc., were supplied to over a dozen correspondents. Advice about bees and bee-keeping was also given to several visitors personally.

Colour plates.—Colour plates of several crop pests were supplied to the Entomologist to Government, Burma, the Economic Botanist, Assam, the Head Master, Government High School, Gurgaon, the Agricultural Teacher, Detroj, Ahmedabad, the Cotton Research Botanist, Parbhani, Hyderabad-Deccan, and the Principal, Atkinson College, Lahore.

Issue of Certificates.—Sealed samples of raw coffee imported by the Imperial Council of Agricultural Research from London, were examined and properly treated under quarantine conditions for the coffee bean borer.

Two hundred and forty-four *Phylloxera* certificates were issued for the export of orchids and other plants.

At the request of the Imperial Agriculturist, samples of wheat and cow-peas were examined and fumigated at Karnal.

V. TRAINING OF STUDENTS

Mr. R. L. Garg, B.Sc. (Agr.), post-graduate student, completed his course in December, 1937. Mr. C. B. L. Bhargava, M.Sc., left in August, 1937, after his first year course, to take up an appointment in the Government College, Ajmer. Mr. R. L. Gupta, B.Ag., continued his work as a post-graduate student in the second year. Messrs. A. K. Kapur, M.Sc., and Mohammad Ahsan, B.Sc., joined as first year students in November, 1937, but the latter left soon after to accept a post in Hyderabad-Deccan.

Mr. Shafi Sarwar, B.Sc., Government College, Lahore, worked in the Section for a short period on white-ants and Mr. A. Salam, B.Sc. (Punjab University) on parasitic mites.

Mr. Govind Ram Shah, M.Sc., from Punjab University and Mr. V. P. Rao, M.Sc., from Benares University joined as research students in July and November, 1937, respectively and are still with us.

Mr. R. L. Gupta has studied the life-history of the leaf miner, *Phytomyza atricornis* Meig., an Agromyzid mining the leaves of a large variety of wild and cultivated plants in several parts of India.

Mr. A. P. Kapur has been studying the bionomics of the Coccinellids *Adonia variegata* Goez and *Brumus suturalis* Fabr. which are predaceous on aphids in Delhi.

Mr. Govind Ram Shah has been working on the bionomics and morphology of the borers of sugarcane. The life-history and habits of various borers are being studied both in the field and the laboratory and the larval chaetotaxy of several of them is also under examination.

Mr. V. P. Rao has been mainly engaged on the study of a collection of Coccidae injurious to fruit trees in Baluchistan, of which the most important species are *Aspidiotus prunorum* Laing, *Parlatoria oleae* (Colvee) Lind., and *Eriochiton* sp. He has also described three species which are new to science.

Mr. A. M. D'Rozario worked in the Section for a short time and consulted the Imperial Entomologist in regard to his proposed programme of study and research at Cambridge.

Mr. Nazeer Ahmad Janjua, Assistant Entomologist, Quetta, and his fieldman had a short course of general training for about 5 weeks.

Before concluding this section, it must be pointed out that since shifting to New Delhi demands from University graduates in Zoology for training in general principles or some particular aspects of Entomology have increased considerably. This is natural as Entomology is one of the most important sciences in an agricultural country such as India, and hardly any Indian University has a trained Entomologist on its staff or proper equipment for teaching Entomology.

VI. MISCELLANEOUS

A note on the control of stored grain pests was supplied to the Director, Delhi Station, for broadcasting.

Dr. R. C. Mundell visited the Section to consult the Imperial Entomologist about his work on the insect enemies of *Xanthium* spp., a weed in Australia.

VII. PUBLICATIONS

The following papers were published during the year under report :—

1. Pruthi, Hem Singh .	Further record of occurrence of Codling Moth in India. *Agr. & Live-Stock Ind.*, 1938.
2. Pruthi, Hem Singh and Samuel, C. K.	Entomological Investigations on the Leaf Curl Disease of Tobacco in North Bihar. Parts I and II. *Ind. Jour. Agric. Sc.*, 1937.
3. Pruthi, Hem Singh and Narayanan, E. S.	The comparative behaviour of some common varieties of sugarcane in reference to the attack of borers at Pusa (Bihar) during 1935-36. *Nat. Inst. Sc. Ind.*, 1938.
4. Pruthi, Hem Singh and Bhatia, H. L.	A New Cecidomyid Pest of Linseed in India. *Ind. Jour. Agric. Sc.*, 1937.
5. Ahmad, Taskhir . .	The Tur pod fly, *Agromyza obtusa* Mall. a pest of *Cajanus cajan*. *Ind. Jour. Agric. Sc.*, 1938.
6. Lal, K. B. . . .	The first Record of the Eulophid genus *Azotus* from India (Chalcidoidea Hymenoptera). *Rec. Ind. Mus.*, 1938.
7. Lal, K. B. . . .	Anti-Jassid Resistance in the Cotton Plant. *Curr. Sc.*, 1937.
8. Narayanan, E. S. . .	A note on *Stenobracon deesae* Cam., a new parasite of the root-borer of sugarcane.

The following papers were submitted for publication during the year under report :—

1. Pruthi, Hem Singh and Batra, H. N.	A Preliminary annotated list of the fruit pests of the North West Frontier Province. *Misc. Bull.* No. 19, I. C. A. R. (In press.)

2. Pruthi, Hem Singh and Bhatia, H. L. — Biology and general morphology of *Leucopis griseola* Fall., an important predator of *Aphis gossypii* and some other aphid pests of crops. *Ind. Jour. Agri. Sci.*, 1938. (In press.)

3. Pruthi, Hem Singh and Narayanan, E. S. — A statistical study of the damage done by borers to sugarcane at Pusa.

4. Pruthi, Hem Singh . — The distribution, status and biology of Codling moth in Baluchistan. *Ind. Jour. Agri. Sci.*, 1938. (In press.)

5. Mani, M. S. . . . — Catalogue of Indian Insects, Part 24—Evanidae.

The following papers were read in the Entomological Section of the Silver Jubilee Session of the Indian Science Congress :—

1. Pruthi, Hem Singh . — Biological Control of Insects in India.

2. Pruthi, Hem Singh and Bhatia, H. L. — Some observations on the bionomics and control of fruit-fly pests in the North West Frontier Province.

3. Ahmad, Taskhir . . — *Pareuderus torymoides* Ferr., an egg parasite of the Amarantus borer, *Lixus truncatulus*.

4. Ahmad, Taskhir . . — A chalcid parasite of the linseed midge, *Dasyneura lini*.

5. Lal, K. B. . . . — The relative efficiency of some methods for comparing jassid population in cotton fields.

6. Bose, B. B. . . . — On *Agrilus citri* Thery (Buprestidae) a pest of *Citrus acida* in Bihar.

The Imperial Entomologist opened discussion on the Protection of Plants against Insects in India at the 2nd meeting of the Board of Agriculture (Crop Wing) at Lahore.

General articles and reviews—

1. Pruthi, Hem Singh . — Review of the methods of fumigation of imported plants in India and elsewhere with suggestions for their improvement. (In the press—for Departmental use only.)

2. Lal, K. B. . . . — Phytopathology—Entomology, 1937 (A review published in the Annual Volume on Biochemical and Allied Research in India, 1937).

VIII. PROGRAMME FOR 1938-39

The work during the next year will be more or less on the same lines as in the past year. Pests of fruits, parasites of cotton bollworms and insect vectors of virus diseases will receive special attention.

* REPORT OF THE SECOND ENTOMOLOGIST (DIPTERIST)

IN CHARGE OF

SCHEME FOR RESEARCH ON INSECT PESTS OF SUGARCANE

(P. V. ISAAC)

Work was conducted at headquarters, New Delhi, and the Sub-stations, Karnal, Pusa and Coimbatore.

At New Delhi study of the seasonal incidence of the borers in sugarcane revealed that the young crop two to four months old was attacked by the stem-borers, *Argyria sticticraspis* Hmpsn., and *Raphimetopus ablutella* Zell., and the root-borer, *Emmalocera depressella* Swinh., while later on up to harvest time, *Scirpophaga nivella* F., was the chief pest prevalent.

At Karnal the following work was done :—

(1) Observations on the seasonal incidence of the major pests on four varieties of sugarcane, Co. 285, Co. 312, Co. 313 and Co. 331, grown in replicated plots, each variety having nine replications. Regular periodical examination of all the dead-hearts produced, for noting the causal agents, was carried out, and the following conclusions were arrived at :—

Scirpophaga nivella F.—This top-borer of sugarcane started its activity in the middle of July and continued right up to the time of the harvest. The number of dead-hearts caused by it steadily increased up to the first week of September after which there was a significant decrease. In July and August the number of dead-hearts produced by this borer was practically the same in all varieties. There was no difference between the resisting capacity of Co. 285, Co. 312 and Co. 313. The variety Co. 331 was found to be comparatively more resistant than the other varieties.

Argyria sticticraspis Hmpsn.—In all the varieties the number of dead-hearts produced by this stem-borer increased rapidly up to the third week of June after which there was a steady fall and was practically zero in the third week of July. The varietal differences were not significant. The pest did very little damage to the stalks.

Emmalocera depressella Swinh.—In the initial stages the extent of attack by this root-borer in all the varieties was the same, and it reached a maximum in the first week of June and was practically nil in the third week of July. In August it again increased. No difference could be said to exist between the resisting capacity of the various varieties to this borer.

(2) Examination was made of all the cane stalks and roots at harvest time, to note the incidence of the borers, on the four varieties, Co. 285, Co. 312, Co. 313 and Co. 331, grown in replicated plots, each variety having nine replications. The examination was done in two sets of plots—one, the Periodical Observation plots in which dead-hearts had been removed at the different periodical examinations, and the other the Final Observation plots which had been left undisturbed throughout the season, and the following conclusions were arrived at :—

(*a*) Attack due to the top-borer, *Scirpophaga nivella* F., was significant in both sets of plots and in all the varieties except in Co. 331

* This represents a summary of the full report submitted to the Imperial Council of Agricultural Research who finance the scheme.

of the Periodical Observation plots. Attack in Co. 331 in the Final Observation plots was significantly less than in the other varieties.

(*b*) The percentage of attack by the stem-borer, *Argyria sticticraspis* Hmpsn., in cane stalks was insignificant. The other stem-borers were found in still less numbers.

(*c*) Percentage of healthy canes in the Periodical Observation plots and Final Observation plots was the same.

(*d*) The weight of canes attacked by *Scirpophaga nivella* F., was significantly less in the Final Observation plots for all the varieties, while in the Periodical Observation plots it was significantly less only for Co. 312 and Co. 331. The average weight of canes attacked by *Scirpophaga nivella* F., was the same for all the varieties in both sets of plots.

(*e*) The number of canes damaged by *Argyria sticticraspis* Hmpsn., at the time of harvest was too small for the estimation of losses in weight due to this borer. A small percentage was damaged by miscellaneous causes such as lodging and mycological diseases other than those dealt with above.

(*f*) There was a significant attack of roots by *Emmalocera depressella* Swinh., in both sets of plots. The percentage of root-borer was significantly more in the case of Co. 331 for the Periodical Observation plots. In the Final Observation plots also the percentage of the root-borer for Co. 331 was more than in the other varieties but the difference was not significant.

(*g*) The percentage of roots attacked by termites in the two sets of plots was significant, but the differential susceptibility of the varieties was not significant.

At Pusa the periodical examination of some varieties of sugarcane to note the incidence of the different pests at different parts of the season revealed that *Scirpophaga* spp., the top-borers, *Diatraea* spp. and *Chilo zonellus* Swinh. the stem-borers, *Emmalocera depressella* Swinh. the root-borer and termites were doing damage throughout the year. Among the sucking insects, *Pyrilla* spp., *Assamia moesta* Westwd., *Trionymus sacchari* Ckll., and *Aleurolobus barodensis* Mask., were common during November and decreased later on.

At Coimbatore work on the mid-rib structure in sugarcane affecting incidence of the top-borer, *Scirpophaga nivella* F., was started. A strong mid-rib appears to afford resistance to the pest.

Biological Control Research

An attempt was made at Cuttack with the co-operation of the Director of Agriculture of Orissa to experiment in the control of the chief borer pest of Orissa, *Argyria sticticraspis* Hmpsn., by means of introducing large numbers of its egg parasite *Trichogramma minutum* Riley. Two similar blocks of sugarcane were chosen for experiment in one of which *Trichogramma* parasites were liberated during February and March 1937, whereas the other block was left untreated as a control. Periodical counts of dead-hearts in the two blocks

and examination of the canes at harvest time during January, 1938 gave the following conclusions :—

(*a*) The dead-hearts produced in the *Trichogramma* distributed block were less than in the control block. The observed difference between the number of dead-hearts produced in the *Trichogramma* released block and the control block was significant, *i.e.*, the number of shoots destroyed by borers in the Control Block was significantly greater than in the *Trichogramma* distributed block.

(*b*) Judging from the percentage of stem-borer in stalks examined at harvest time there was some evidence to the fact that *Trichogramma* was effective in checking the population of the stem borer, *Argyria sticticraspis* Hmpsn.

Pyrilla studies

Spraying experiments carried out in the laboratory early in 1938 showed that soap solution at the rate of 1 lb. of soap in 20 gallons of water gave satisfactory kill against nymphs.

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